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Proceedings of the First Annual Meeting of the Pacific Slope Branch of the American Association of Economic Entomologists

The first annual meeting of the Pacific Slope Branch of the American Association of Economic Entomologists was held in the library of the San Diego High School, San Diego, Cal., August 10 and 11, 1916.

Because of the isolation of the place there was not a large attendance, but the meetings were interesting and profitable.

The business was interspersed with the papers, the proceedings occupying the afternoon of August 10 and the forenoon of August 11.

Because of the absence of Dr. E. D. Ball, Chairman, the meetings were called to order at 2.30 o'clock p. m., August 10 by the secretary, who explained the formation of the Pacific Branch and the discontinuation of the Pacific Slope Association of Economic Entomologists. A number of members of this latter organization who presented ap-ications to join the branch were present and took part on the pro-am.

The first matter placed before the convention was the election of a airman. Prof. H. J. Quayle was elected and presided over the eetings.

During both sessions twenty-one members and visitors were present. The following members were in attendance:

L. Crawford, Claremont, Cal.	L. P. Rockwood, Forest Grove, Ore.
O. Essig, Berkeley, Cal.	H. S. Smith, Sacramento, Cal.
J. Quayle, Riverside, Cal.	E. G. Titus, Logan, Utah.

Upon a motion of the house which was duly seconded and carried the airman appointed the following nomination committee: E. G. Titus, Chairman, H. S. Smith.

The regular program of the day was then taken up.

Chairman H. J. Quayle: The first paper on the program by W. M. Davidson will be read by the secretary.

ECONOMIC SYRPHIDÆ IN CALIFORNIA[1]

By W. M. Davidson, *Scientific Assistant*, U. S. Bureau of Entomology, Deciduous Fruit Insect Investigations

The *Syrphidæ* have long been looked upon as an important factor in the control of plant-lice and other homopterous insects, and although there are a few species injurious to cultivated plants our present knowledge plainly indicates that the balance is very heavy on the beneficial side.

California is rich in beneficial species, the majority of which belong to the tribe *Syrphini* which is centered around the type genus *Syrphus*. These species prey almost exclusively on plant-lice, the species *Baccha lemur* Osten Sacken attacking mealy-bugs (*Pseudococcus*) and *Sphaerophoria sulphuripes* Thomson being predaceous on the Bean Thrips (*Heliothrips fasciatus* Perg.) in southern California.

Just as we have imported from Europe many injurious aphidids, e.g., *Aphis pomi* DeGeer, on apple, pear, loquat; *Hyalopterus arundinis* Fabr., on prune and plum; *Aphis rumicis* L., on bean; *Aphis medicaginis* Koch on leguminous crops; *Macrosiphum pisi* Kalt., on peas; *Aphis brassicæ* L., on cruciferous crops; *Chromaphis juglandicola* Kalt., on walnuts, so there have come to us some of their syrphid enemies. By far the most important of these is *Catabomba pyrastri* L. This species finds a home throughout California and in certain years becomes extremely abundant wherever severe aphidid infestations occur in orchard or field. Two such years in central California were 1912 and 1914. The adult fly is easily recognizable by its large size and by the three pairs of lunate whitish-yellow spots on the abdominal disc. A melanoid variety of the female (*unicolor*) is spotless and this form is rare except in years when the species is especially abundant. In 1914 the variety was very abundant while in 1913 and 1915 very few could be observed. The pale green, white-striped larvæ are voracious feeders. They may consume a thousand plant-lice of average size in the course of their two or three weeks' larval existence. They appear first early in March and thus have a start of the ladybird beetles and other predators which do not appear much before April. About the first of March the adult flies begin ovipositing among colonies of winter-feeding plant-lice such as *Macrosiphum rosæ* L., on roses and *Macrosiphum solanifolii* Ashm. on weeds such as filaree (*Erodium*) and toward the end of the month eggs are placed among young colonies of orchard aphidids the stem-mothers of which hatched from the winter eggs in February and early March. It is not common

[1] Published with the permission of the Chief of the Bureau of Entomology.

to find this latter type of aphidids attacked before they have secured a good start, a phenomenon which suggests a balance of nature which strives to provide enough food for future generations of syrphids by guarding against the wholesale destruction of the young stem-mothers. If the adult flies that issue early in spring confined their attention to the young stem-mothers of the orchard aphidids, the latter would be either wiped out or so restricted that there would not be food for the future generations of flies.

Throughout summer and fall the larvæ of *Catabomba pyrastri* attack all varieties of injurious aphidids that they can reach. The species must be credited with enormous destruction among plant-lice. All things considered it is one of the most beneficial insects in California, vieing with such well-known species as the Vedalia (*Novius cardinalis*), the Chalcidine scale parasites, and *Hippodamia convergens*.

In California there are about 14 species of *Syrphus*, 9 of which are either quite uncommon or confined to mountain districts. However *S. ribesii* L., *S. torvus* Osten Sacken, *S. americanus* Wied., *S. opinator* Will., and *S. arcuatus* Fallen attack injurious plant-lice in appreciable numbers. Very beneficial are the two most abundant of them, *S. americanus* and *S. opinator* whose larvæ are general feeders and may be taken frequently among colonies on cultivated plants. The larvæ of *S. arcuatus* occur in early spring on coniferous plants feeding upon aphidids occurring thereon and later they attack principally such semi-protected species as *Aphis malifoliæ* Fitch on apple. Like *torvus* and *ribesii*, *arcuatus* is common to Europe and North America. All the members of the genus in California have yellow or reddish-yellow transverse bands on the abdomen. In *arcuatus* the three principal bands are interrupted, while in the others above mentioned only the first band is interrupted. The larvæ are brown, yellow or purple and the puparia brown. The larvæ are not so large or voracious as those of *Catabomba pyrastri*. Closely allied to *Syrphus* is a common species, *Eupeodes volucris* Osten Sacken. This fly is marked like the members of the genus *Syrphus* but is somewhat smaller, albeit large examples of the female are almost indistinguishable from the female of *Syrphus arcuatus*. The larvæ have been bred from injurious and other plant-lice.

The genus *Sphærophoria* is represented in California by three species, *Sph. melanosa* Will., *Sph. sulphuripes* Thomson and *Sph. micrura* Osten Sacken, of which the two first at least are aphidophagous in the larval stage. These are common flies, narrow-bodied and small, and are peculiar in having extra segments to the abdomen. They are blackish with bright yellow cross-bands. The larvæ and puparia are green and the pupæ commonly occur on the plant on which the larvæ

have been dwelling, in this respect differing from the species previously discussed in which the larvæ pupate in loose soil or rubbish at the base of the plant. The larvæ of *Sphærophoria sulphuripes* also prey upon the Bean Thrips (Russell, The Bean Thrips, U. S. D. A., Bul. 118, 1912).

Allograpta obliqua Say is a well known enemy in southern California of the citrus and truck crop plant-lice. Further north the fly is less common and it has been bred from the walnut aphis (*Chromaphis juglandicola* Kalt.). *A. fracta*, a rarer species, is presumably aphidophagous. The adult flies are rather small. They have yellow cross-bands and in addition longitudinal and oblique yellow markings on the fourth and fifth segments.

In the allied genus *Mesograpta* there are two common California species, *M. geminata* Say and *M. marginata* Say. These are small species, shining black with yellowish-red abdominal markings. Their economic standing appears to be unknown while the eastern *M. polita* Say is an injurious form, attacking corn plants and sometimes causing them to wither badly.

Baccha is a genus of slender elongate flies, in which the body is more or less constricted basally. The larvæ of *B. lemur* Osten Sacken have been bred from the citrus mealy-bug (*Pseudococcus citri* Risso) ("Mealy-Bugs of Citrus Trees," Univ. Cal.; Coll. Agric. Bul. 258, C. P. Clausen) and other mealy-bugs (Cal. State Comm. Hort. Mo. Bul., vol. IV, 4, E. O. Essig) in southern California where the species is common. The larval habits of *B. obscuricornis* Lœw (? *B. elongata*), found about San Francisco Bay are unknown. Elsewhere other species of *Baccha* have been reported (*e. g.*, "Syrphidæ of Ohio," Ohio State Univ. Bul. XVII, 31, C. L. Metcalf) as preying in the larval stage upon aphidids, coccids, leaf-hoppers and white-flies.

The two aphidophagous genera *Pipiza* and *Paragus* belong to the tribe *Chilosini*, a group in which the larvæ chiefly inhabit stems and stalks of hollow plants. *Pipiza pisticoides* Will. and *P. albipilosa* Will. are rather small, black, shining species and bear much short white pile. They are both common in California and their larvæ feed on protected or semi-protected plant-lice such as *Pemphigus populicaulis* Fitch on poplar. It is doubtful whether these are of much economic importance but further study might alter this opinion, as both *P. modesta* Lœw and *P. radicum* Walsh & Riley occur in the East upon the woolly apple aphidid (*Eriosoma lanigerum* Haus.) and *radicum* preys also upon the grape phylloxera (*Phylloxera vitifolia* Fitch). The *Pipizæ* larvæ in California are dark green or greenish-brown and the puparia brown. Both larvæ and pupæ are somewhat more robust and roughened than those of the *Syrphini*.

Paragus tibialis Fallen and *P. obscurus* Meigen, whether considered as two valid species or as two varieties of a single species, are common flies. The adults are small shining black or reddish-black flies. The larvæ are aphidophagous; that of *tibialis*, according to Metcalf (Ohio State Univ. Bul. XVII, 31) is light yellowish-brown. The small size of these species rather militates against their economic importance. The larvæ feed on aphidids attacking such semi-aquatic plants as dock.

Of all these species mentioned above the most important economically are in order probably *Catabomba pyrastri*, *Syrphus opinator*, *S. americanus*, *S. arcuatus*, *Allograpta obliqua*, and *Eupeodes volucris*. The first named probably outweighs all the others together.

In California syrphid larvæ are frequently the victims of Ichneumonid parasites belonging to the genera *Bassus*, *Syrphoctonus*, *Homotropus* and perhaps others. They are also parasitized by Chalcids. At times large numbers of the adults are destroyed by fungi, one such outbreak being noticeable in the spring of 1914, in central California.

Two injurious species of *Syrphidæ* have recently been found in California and both are importations from Europe. The Narcissus bulb-fly (*Merodon equestris* Fabr.) is apparently now established in central California and *Eumerus strigatus* Fallen, said to be injurious to onion bulbs in Europe, has apparently become established in the San Francisco Bay region. Both of these species have been taken on the wing on several occasions. Their larvæ dwell inside the bulbs and may cause their destruction. *Merodon equestris* is a large hairy robust fly somewhat resembling a bumblebee while *Eumerus strigatus* is a small, black shining, almost bare, species. *Copestylum marginatum* Say and species of *Volucella* in their larval stages inhabit the interior of cactus leaves and stems and may cause injury to the host (Cf. "Principal Cactus Insects of United States," W. D. Hunter, F. C. Pratt, J. D. Mitchell, U. S. D. A., Bul. 113, 1912).

CHAIRMAN H. J. QUAYLE: This paper is now open to discussion.

SECRETARY: The following communication from H. E. Burke regarding this paper has been received and is as follows:

"I would be glad to be there at the discussion of Mr. Davidson's paper to call attention to the damage done by the larvæ of some forest *Syrphidæ* to our timber. The larvæ (bark maggots) of *Cheilosia* and probably other genera cause serious defects (black checks) in the wood of much of our white fir (*Abies concolor*), red fir (*Abies magnifica*) and hemlock (*Tsuga heterophylla*). In most discussions of the *Syrphidæ* the injurious habits are not given."

CHAIRMAN H. J. QUAYLE: The next paper by G. F. Moznette will be read by the secretary.

THE FRUIT-TREE LEAF SYNETA, SPRAYING DATA AND BIOLOGICAL NOTES[1]

By G. F. Moznette

During the past spring the prune and cherry growers of the Willamette Valley in Oregon had considerable loss due to the ravages of the Fruit-Tree Leaf Syneta, *Syneta albida* Lec. The species is a member of the family *Chrysomelidæ* and is primarily a leaf feeder. However, at the time this species is particularly abundant, the young developing fruit of the cherry and prune is severely attacked. The injury which consists of a pitting to the fruit causes it to be scarred or blemished so badly that it is rendered unmarketable, and it may also ripen prematurely and fall (Pl. 31, fig. 1). In many cases the stems are also badly nibbled (Pl. 32, fig. 2). In the case of the cherry and prune particularly, the beetles seem to prefer the tender fruit to the leaves and petals (Pl. 33, fig. 3); these, however, are often eaten severely and cause considerable alarm. Fortunately the species in puncturing the petals, an injury which is often very conspicuous, does not injure the fruit-forming parts of the flower (Pl. 33, figs. 3, 4). Considerable injury is also caused to the foliage of young trees, and often means the death of the grafts when the individuals are abundant.

Investigation into the distribution of this species shows it to be confined to the Pacific Coast. The species is found from Western British Columbia south to Alameda county on San Francisco Bay. Upon examination of specimens in the writer's collection individuals are recorded as collected from Contra Costa County, Oakland and Nashmine in California by Dr. E. C. Van Dyke. Other specimens were taken at Seattle, Port Angeles and Monroe in Washington. It is fairly well distributed over the entire Willamette Valley, Oregon, particularly in the northern part. Specimens collected in British Columbia were taken at Vernon. The species was not known to exist east of the Cascade Mountains but recently a report was noticed in which Mr. M. A. Yothers[2] reports it as being a serious pest to apple at Walla Walla, Washington. He also reports it from Puyallup, Washington, near Seattle.

Upon examination the species was found to be exceedingly variable in coloration, apparently according to its typographical distribution. The male possesses subacute angulations at the sides of the thorax without denticulations. The costæ in this species are very variable

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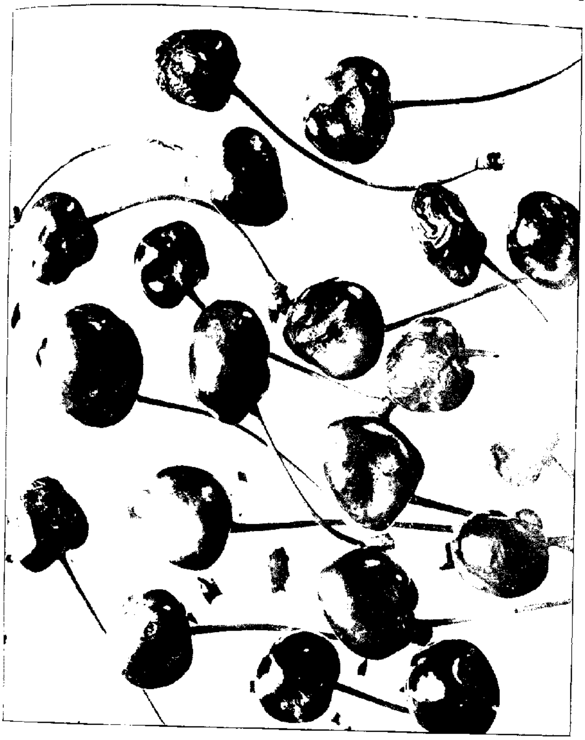
[1] Contribution from the Entomology Department of the Oregon Agricultural College.

[2] Bul. No. 124, Bud Weevils and Other Bud-eating Insects of Washington, by M. A. Yothers, Pullman, Wash.



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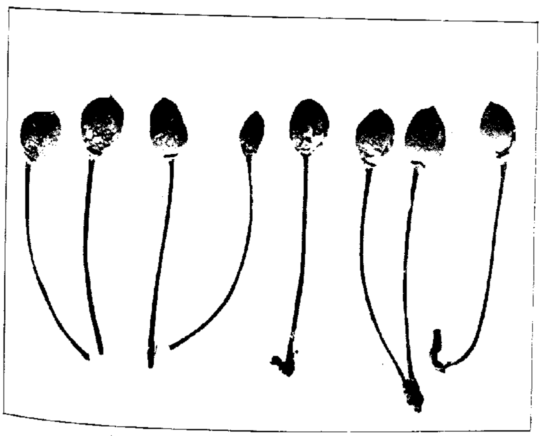

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and may be entirely absent. The color is usually a grayish-white to testaceous with the suture nearly black. The posterior tibiae are simple with terminal spurs. The female is usually a yellowish-white and varies less in color than the male. The forms recorded from Nashmine in Trinity County, California, at an elevation of 5,000 feet, are much larger than are any of the individuals collected at other points in California and at points to the north. The species has not been found south of San Francisco Bay, occasionally one may be found in the hills near Oakland, California. In that region it is often confused with a variety of an allied species, *Syneta simplex* Lec., which is usually the most destructive to fruits in sections of California,[1] and occurs in greater abundance than does *Syneta albida* Lec. Specimens recorded from Port Angeles, Washington, are very dark in appearance, the dark brown approaching a black. A specimen taken at Yaquina Bay in Oregon is a deep red in color. The striations on the elytra of both sexes, which is a characteristic distinguishing it from the existing species, vary greatly according to the locality in which they are found. A more detailed account of the variations of this species is intended to be incorporated in a later paper on the revision of the genus *Syneta*.

The original host of this species is not known to the writer. In many instances the beetles were found working on vine maple and hazelnut trees which may possibly be their native hosts. Among the fruit trees which are attacked may be listed the apple, cherry, prune, pear, quince, plum and wild crabapple. Occasionally the small fruits, as currant and gooseberry, are attacked.

Due to the fact that considerable alarm existed among the orchardists of the Willamette Valley, a series of spraying experiments were conducted in a preliminary manner to test the efficiency of a few sprays as killing agents or as repellents. At the time when this insect is doing its destructive work the precipitation in western Oregon is very heavy. This is during April and May. Hence it is absolutely essential that the spray materials possess adhesive and colloidal properties. This year the adults were particularly numerous from the last of April until the last of May.

In the experiments conducted the sprays were applied after the beetles had already done some damage, but as the beetles are capable of living from a month to six weeks fairly good data could be obtained from the action of the sprays used under our climatic conditions. The following applications were applied to Italian prunes on the place of Mr. C. O. Constable at Salem, Oregon, in May, a short while after the petals had fallen or just after the shucks had fallen: Black Leaf 40

[1] Injurious and Beneficial Insects of California, E. O. Essig, Cal. State Com. of Horticulture, Sacramento, Cal.

at the rate of 1–400 plus lime-sulphur 1–35, fifty trees sprayed; white hellebore 2 lbs. to 50 gallons of lime-sulphur 1–35, fifty trees sprayed; triplumbic arsenate of lead, 3 lbs. to 50 gallons of lime-sulphur 1–35, sprayed 100 trees. The rest of the orchard was sprayed with regular neutral lead arsenate 2 lbs. to 50 gallons of lime-sulphur 1–35. A few cherry trees were also sprayed with this material to test for burning properties as well.

The results of these preliminary experiments showed that due to our excessive rains at intervals the Black Leaf 40 and white hellebore, when used with lime-sulphur, cannot be relied upon as they are subject to being washed away. A short while after the trees were sprayed the foliage upon examination was very badly eaten into and many of the small fruits pitted. In check experiments carried on at Corvallis where the beetles were confined in cheesecloth bags over apple trees, it was found that the beetles did not seem to mind the Black Leaf 40 and white hellebore when used alone and ate very voraciously of the foliage. At Salem, Oregon, it was observed that the regular arsenate of lead when applied in greater strengths than 2 lbs. to 50 gallons of lime-sulphur 1–35 cannot be used with safety on the tender cherry foliage. The triplumbic arsenate of lead gave very good results and may be used in greater strengths than the regular neutral arsenate of lead on cherry and prune foliage. The Italian prune trees where the arsenate of lead was used were less riddled, the prunes were cleaner from pitting and occasionally one or two beetles could be shaken from the trees. The arsenate of lead, both triplumbic and the regular neutral, showed very good adhesive properties when used with lime-sulphur and the foliage was well coated two weeks after the applications in spite of our excessive hard spring rains. It is possible that the triplumbic arsenate of lead may be used at greater strengths than was used with good results on the foliage of cherry and prune.

In this state where the brown rot of stone fruits, *Sclerotina fructigena*, is prevalent and spraying operations must be conducted against it in the case of cherries and Italian prunes and plums, combination spraying should be practiced more extensively, in those sections where the two evils exist.

In the case of prunes, plums and cherries which are sprayed for brown rot just after the blossoms open with Bordeaux Mixture 4-4-50 or lime-sulphur 1–35, arsenate of lead should be added 3 lbs. to 50 gallons of the spray, and preferably the triplumbic arsenate of lead as the foliage of cherry particularly is very susceptible to arsenic injury. In the spray against brown rot and Coccomyes (Cylindrosporium), the leaf spot or shot hole to be applied 10 days or two weeks after the shucks fall, add arsenate of lead 3 lbs. to 50 gallons of the spray. At

this time Bordeaux is used at the rate of 4-4-50; and lime-sulphur at the rate of 1-50. In the case of the apple and pear, arsenate of lead may be added at the rate of 3 lbs. to 50 gallons of lime-sulphur in the "pink" for apple scab, *Venturia pomi*. The arsenate of lead incorporated against the codling moth will be sufficient in subsequent sprays for the apple and pear.

Explanation of Plates 32, 33

1. Cherries pitted and deformed by *Syneta albida* Lec.
2. Young cherries pitted and stems gnawed, adults.
3. Apple showing the characteristic work of the adults on foliage.
4. Injured and uninjured apple blossoms.

Chairman H. J. Quayle: The next paper will be by E. O. Essig on the chrysanthemum gall-fly.

THE CHRYSANTHEMUM GALL-FLY, DIARTHRONOMYIA HYPOGÆA (F. LÖW)

Cecidomyia hypogæa F. Löw, Verh. Zoöl.-Bot. Ges. Wien. XXXV, p. 488, 1885. (Figures 1-7)

By E. O. Essig, *Agricultural Experiment Station, Berkeley, California*

Though the chrysanthemum gall-fly has been known as a pest in Europe for many years it was not recorded as occurring in the United States until April 1915 when Dr. E. P. Felt received specimens from Prof. R. H. Pettit of Michigan.[1] In September of the same year Mr. C. C. Barnum, a student at the University of California, called attention to the work of a gall-fly on chrysanthemums growing in a greenhouse on the campus. From the infested plants the writer reared a large number of adults, some of which were forwarded to Dr. Felt who kindly determined them as the above and gave the published records of its previous occurrence in this country. Since that time the writer has made a general survey of the central part of the state and has found that the insect is quite abundant and destructive in the region of San Francisco Bay.

Description

The larvæ or maggots (Fig. 32 B) are very small, averaging only about 1.5 mm. in length and 0.8 mm. in diameter when full-grown. The shape is somewhat cylindrical with the anterior end more or less pointed and the posterior end broadly rounded. The color varies from transparent-white to pale yellow or orange.

[1] Jr. Econ. Ent. VIII, p. 267, April 1915.

The pupae (Fig. 32 C) are about the same size and shape as the larvae but are slightly larger at the anterior end. The color is white or pale-yellow with amber

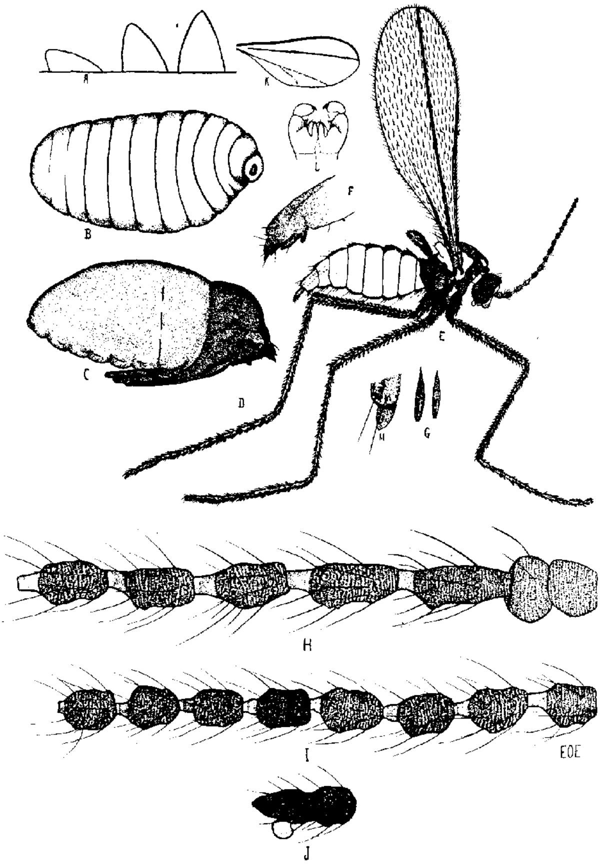

Fig. 32. The chrysanthemum gall-fly, *Diarthronomyia hypogaea* (F. Löw). *A*, galls as they appear above the surface of the plant; *B*, larva; *C*, pupa; *D*, enlarged anterior projections of same; *E*, adult female; *F*, ovipositor of female; *G*, scales from legs; *H*, *I*, *J*, sections of the antenna; *K*, wing showing slight variations; *L*, genitalia of male; *M*, palpus. Enlarged. (Original).

markings on the anterior region. There are two pairs of prominent tooth-like projections at the head, the first pair being noticeably larger than the second. The color of these projections is somewhat darker than the surrounding tissues.

2

3

4

5

The adults or flies (Fig. 32 E) are exceedingly delicate with noticeably long and slender legs. The head, antennæ, thorax and the base of the abdomen are dusky amber, the legs light-amber with light-colored femora; the abdomen bright or pale orange-red; and the eyes very dark-red. The wings are transparent or faintly smoky and covered with many scale-like hairs. The legs are also thickly beset with similar hairs or scales which are noticeably wider at the tip or somewhat spatulate-shaped (Fig. 32 G). The palpi (Fig. 32 M) are two-jointed and the antennæ (Fig. 32 H, I, J) are 16-jointed and normally hairy. The body is slender and averages 1.5 mm. in length.

Life-History

The habits of the insect have been under observation for only part of a year, but long enough to gain a fair idea of the main points in the life-history. During the summer months of August, September and October the maximum development is reached and there are great numbers of all stages after which there is a gradual reduction until the following spring and summer. The adults of the summer brood give rise to a very large number of maggots which hibernate in the galls on the leaves and stems of the plants. These reach maturity in the spring and give rise to the summer brood so that there appear to be but the two broods during a year. There is some overlapping of the broods since adults may issue as late as January and a few pupæ hibernate. The writer has been informed by florists, who have been acquainted with the habits of the insect for years, that the adults swarm in the greenhouses as early as five o'clock in the morning during the summer and that during the day they are not to be found. The former observation has not been substantiated, but the latter was carefully studied and it was found that though the adults could be found at all times during the day they were usually resting on the plants and seldom ever on the wing, though they were seen to fly freely at times but only when disturbed.

Nature of Work

As the common name implies, this insect produces galls which are very characteristic and may be found on the leaves, leaf-petioles, stems and buds of the food plants. The galls (Fig. 32 A, and pls. 34, 35, fig. 2–5) are decidedly cone-shaped and the main axis may be at right-angles or at an acute angle to the main axis of the leaves, stems and buds. Very often they may be almost wholly enclosed within the tissues so that only the tips are exposed. The greatest numbers are to be found on the tender shoots on both sides of the leaves, on the stems near the tips and on the buds. Infested shoots are often distorted beyond recognition (Pl. 35, figure 5) and are eventually killed. The color is first somewhat lighter than the surrounding tissues, but in time become bright red or brown. The size of the fully-developed

galls is quite uniform averaging about 3 mm. in length and 1 mm. in diameter at the base. They are most abundant during the fall and winter months. In many of the chrysanthemum growing districts in the San Francisco Bay Region as much as one third of the crop is annually lost unless preventive or control measures are adopted. Two florists at Alameda who at one time grew large numbers of cut flowers claim that the fly forced them out of business. Plants grown in greenhouses are injured most, but the attacks are also very severe in lath houses. Plants growing out-of-doors in the average house garden do not appear to become infested, at least a careful inspection has so far failed to discover such, and infested plants taken from a greenhouse or a lath house rapidly recover when placed outside where there is no protection from the elements. Last August the writer secured twenty-one infested plants from a greenhouse and set them in his garden. On all of the new growth which has appeared to date (February 24) there is not a single gall to be found, while checks left in the greenhouse and removed to a lath house are either still badly infested or are entirely ruined. It is perfectly possible however to conceive of a condition outside in a particularly protected and warm place where the insect may continue to breed.

Distribution

As previously stated the chrysanthemum gall-fly was first taken by the writer in California at Berkeley, though investigations show that it has been known to florists for over fifteen years in other places around San Francisco Bay. The writer has taken it in Alameda, San Francisco and San Mateo Counties. It probably occurs in the other counties which have not been visited. A single infested shoot of a chrysanthemum was received last fall from Mr. Arthur E. Beers, County Horticultural Commissioner, from Merced and it is not unlikely that the insect is distributed throughout the state where chrysanthemums are grown commercially.

Food Plants

The favorite food plant of this insect is the cultivated chrysanthemum, some strains of which are more susceptible to attack than others, but all appear to suffer to some extent at least. The ox-eye daisy (*Chrysanthemum leucanthemum*) is listed as a host in Europe.[1]

Control

The practice of growing the bulk of the chrysanthemum crop under cloth has been one of the chief means of preventing the attacks of the

[1] Kertész, C., Catalogus Dipterorum, II, p. 69, 1902.

chrysanthemum gall-fly and is by far the most efficient and satisfactory way of handling the situation. The young clean selected plants are propagated from the beginning in these insect-proof cloth houses and every precaution is taken to keep them clean and tight.

In greenhouses the difficulties are very great. Eliminating all infested plants and using only clean cuttings have given fairly good results, but means a continual fight from the very beginning to pre-

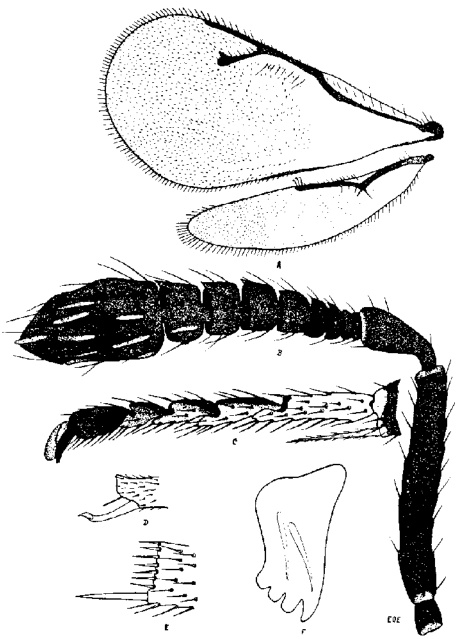

Fig. 33. Some detail anatomical characters of *Amblymerus* sp., a parasite of the chrysanthemum gall-fly. *A*, wings; *B*, antenna; *C*, middle tarsus; *D*, tibial spur on front leg; *E*, tibial spur on hind leg; *F*, mandible. Greatly enlarged. (Original).

vent reinfestation. Some florists take only underground cuttings from infested plants and get satisfactory results when all of the old plants are destroyed before the flies begin to emerge in the spring.

In lath houses there is continual danger of infestation which can hardly be avoided. One practice which works very well where the old plants are allowed to come up again during the winter and spring is to cut back the young shoots in November or December and again in February or March and burn the trimmings. In this way most of the

hibernating larvæ are destroyed and much of the crop may mature in good condition.

Nicotine sulphate or "Black Leaf 40" used in the proportions of 1 to 1600 of water will give temporary relief if applied once or twice, but to get good results it must be used every two or three weeks from June until just before blossoming time.

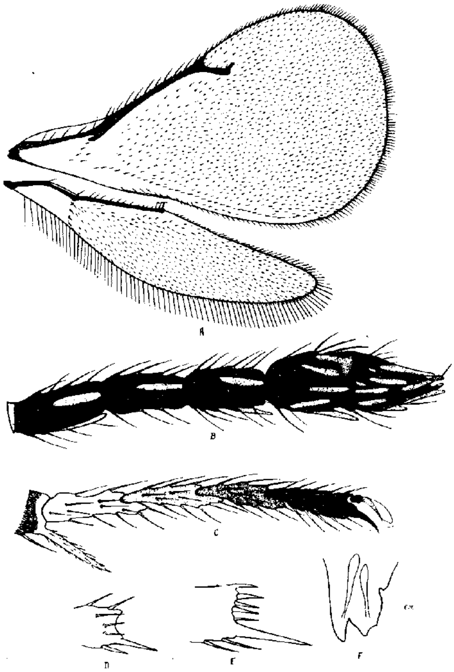

Fig. 34. *Tetrastichus* sp., a parasite of the chrysanthemum gall-fly. Detail drawings: *A*, wings; *B*, last five joints of the antenna; *C*, middle tarsus; *D*, tibial spur of front leg; *E*, tibial spur of the hind leg; *F*, mandible. Greatly enlarged. (Original).

Parasites

During the summer a large number of parasites were reared from infested plants and one species in particular did excellent work in the University greenhouse. The material was sent away for determination and a few observations made as follows:

Amblymerus sp. This hymenopterous parasite has been described by Mr. A. A. Girault, through the kindness of Dr. L. O. Howard, and

a description is to appear elsewhere. The adults are black with yellow markings on the legs. The females vary from 1 mm. to 1.2 mm. in length and the males are somewhat smaller. Some of the details in figure 33 will aid in distinguishing it. The larvæ live within the galls alongside the maggots of the gall-fly which they gradually consume. They remain within the galls until mature when they emerge through small circular holes. This species is the most abundant during the summer months and all of the adults were reared during August, September and October. In not a few cases as high as 80 per cent to 90 per cent of the maggots were destroyed.

Tetrastichus sp. (Fig. 34). The generic determination of this insect was made by Mr. Harry S. Smith, Superintendent of the State Insectary, Sacramento, California. It is also a small black parasite somewhat larger than the former and easily distinguished from it by the four-jointed tarsi and other characters shown in the accompanying drawings.

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[1] Since preparing this article some months ago the writer has received a copy of the 31st Report of the State Entomologist of the State of New York, June 1, 1916, from Dr. Felt and finds that the subject matter is much more thoroughly handled and that this paper would not be worth printing were it not for the local interest to California.

The above bibliography is taken entirely from Dr. Felt's paper with a rearrangement and a few minor changes.

Other localities given in Dr. Felt's paper are Oregon, and Ottawa, Canada, and the additional European host plants: *Chrysanthemum corymbosum*, *C. atratum*, *C. japonicum* and *C. myconis*. The varieties of *C. japonicum* are very generally infested in this district.

The technical description of the various stages is very complete in the above mentioned paper.

EXPLANATION OF PLATES 34, 35

Fig. 2. Chrysanthemum leaf showing newly formed galls of the chrysanthemum gall-fly on the under surface. Enlarged. (Original. Photo by Dept. Sci. Illust., U.C.).

Fig. 3. Stem of chrysanthemum showing the galls made by the chrysanthemum gall-fly. The round holes were made by parasites. Enlarged. (Original. Photo by Dept. Sci. Illust., U. C.).

Fig. 4. Tip of young chrysanthemum plant showing fully-developed galls of the chrysanthemum gall-fly. The galls were dark red and mostly on the upper surfaces of the leaves. (Original. Photo by Dept. Sci. Illust., U. C.).

Fig. 5. Young shoot of chrysanthemum plant showing the deformity due to the galls made by the chrysanthemum gall-fly. This is a fair example of the work in greenhouses and lath houses when control measures are not employed. Enlarged. (Original. Photo by Dept. Sci. Illust., U. C.).

CHAIRMAN H. J. QUALE: The next paper by Mr. E. Ralph de Ong on the Municipal Control of the Argentine Ant will be read by the secretary.

MUNICIPAL CONTROL OF THE ARGENTINE ANT

By E. RALPH DE ONG, *Instructor in Entomology, University of California*

The Argentine Ant was first recognized in California about 1908, at only eight points in the state but has since spread to most of the larger cities on the coast. The list of known infested towns in 1916 being as follows; San Diego, Corona, Riverside, Upland, Claremont, Azusa, Monrovia, Los Angeles, Montecito, Santa Barbara, Santa Maria, Salinas, San Jose, Cupertino, Saratoga, Redwood City, San Mateo, Burlingame, San Francisco, Alameda, Berkeley, Oakland, Piedmont, Stege, Martinez, Byron Hot Springs, Stockton, Sacramento, and St. Helena. In many of these towns the infested area is comparatively small but steadily increasing while in others, for instance Alameda, practically the entire town is infested.

Here is an example of a most annoying house pest spreading in a few years' time in scattering colonies over a strip of territory, 700 miles long, without any systematic effort being made to check its invasion. Carried from city to city by commerce they gain a foothold and slowly but surely spread out on every side in spite of the thousands of dollars spent by the householders and the hosts of ant remedies for sale; even a list of which is too cumbersome for this paper. Thirty-nine arsenical ant remedies have been recorded in this state alone, the percentage of metallic arsenic ranging from 12 per cent to .2 per cent. The great majority of these are strong percentages of arsenic which are not effective in control work on this ant and are unsafe to have on the premises, especially where there are children.

In the fall of 1908 the University established a laboratory in East Oakland for the study of this pest, part of the results of which were published in October 1910, including the formula for a weak arsenical solution that has proven so effective as a control measure. To L. H. Day, an assistant in the laboratory, is due the first proof of the greater efficiency of this strength of poison.

About this time the City of Berkeley appropriated five hundred ($500.00) dollars for a campaign against the pest; this work was carried on by L. J. Nickels[1] under the plan outlined by Professor Woodworth. At this time there were but two small colonies in Berkeley, one covering about two blocks, the other parts of four blocks. Considering the seriousness of the pest and the smallness of the infestation, it was considered advisable to attempt eradicating the ants. A careful survey was made and every effort used to secure the coöperation of all residents in the affected areas, to the end that all supplies of food except the poisoned bait might be shut off from the ants as far as possible, ant syrup in small perforated containers was placed in every lot. To supplement the poisoned bait a solution of cyanide (2 oz. sodium cyanide to 1 gallon of water) was used on the nests wherever found, the entire expense of labor and material being borne by the city. The manufacture and distribution of the ant syrup was done entirely by Mr. Nickels or an assistant. This plan was tried for several months and although the ants were not exterminated they were controlled, and to the extent that invasions of houses in the infested areas immediately ceased or were rare and of short duration and after a time were unknown; even at a time of the year when they are most annoying and though the ants were present in the yard. Control, that is freedom from ants as a house pest, was attained although the desired result, eradication, was not achieved. This immunity was attained by thus reducing their numbers. When the ants can be controlled so that they are not a serious pest and the territory is not increasing the work justifies the effort.

Because some of the Berkeley colonies crossed the line into Oakland it was very evident that eradication would be impossible without joint action with that city, therefore a successful effort was made to extend the work to the Northern section of Oakland.

It was soon seen, however, that eradication was going to be an impossibility, at least with the funds that could be made available, and the whole attempt was dropped.

In 1915 the City of Piedmont took official recognition of this pest and asked the University for assistance in carrying on control work. At this time only four or five blocks of the town were known to be

[1] Jour. Econ. Ent. IV, 4, Aug. 1911.

infested and a somewhat similar campaign to the one in Berkeley and Oakland was carried on by the author. This effort differed from those previously undertaken in that no attempt was made to eradicate but from the first the idea was control. As a control measure the previous campaigns had been completely successful.

The method consisted in the use of paraffined paper bags, perforated at the bottom to allow free access of the ants. In this bag was placed a sponge saturated with the ant syrup. The formula for this syrup is as follows:

[1]1 oz. sodium arsenite;
16 lbs. sugar;
Water to make three gallons of syrup.

A supply of the prepared bags was placed in convenient places in the infested yards and the sponges refilled as often as necessary. In some cases cyanide solution was used on the nests. Preparation and distribution of the material was done by one man working part time in the employ of the city. He also answered all calls for assistance to any part of the city and whenever an infestation of Argentine ants was found, work was begun in that vicinity.

Piedmont was peculiarly subject to new infestations since the greater part of their potted plants, nursery stock, manure, and building materials are brought from the adjoining city of Oakland, which even at this time contained large areas of ant infested territory and had ceased doing anything to control them. In this way new infestations are constantly begun in Piedmont but by prompt control measures the spread of the ant was restricted and also the annoyance to householders was almost completely eliminated. City control was continued for about three years; the first year the total cost was three hundred ($300.00) dollars, the second year, on account of several new infestations, the expense was slightly more but less than four hundred ($400.00) dollars and this for a total area of sixteen blocks scattered in every part of the city, besides inspection of the entire city. In the third year small tin cans were substituted for the paper bags, this reduced the amount of refilling necessary as larger amounts of syrup could be left in the containers so that in spite of an increased territory, the cost remained about the same. The work was dropped at this time from lack of funds.

[1]Instead of buying prepared sodium arsenite (which is quite variable in strength) it is now made according to the following formula.

1 oz. white arsenic;
2 oz. sal soda or 1 oz. sodium hydroxide;
8 oz. water.

Boil until clear and combine with 16 pounds of sugar and sufficient water to make three gallons.

During this time the infested areas in the adjoining cities of Berkeley, Oakland, and Alameda had increased enormously in spite of the work done by the residents to control the ants; in some cases a single family would spend from twenty to thirty dollars a year for ant pastes and yet not control them. Alameda was now practically a solid infestation, Oakland has perhaps half its territory infested. In Berkeley the infestation had increased from five blocks to one hundred and sixteen or twenty while in Piedmont the increase had been from four to about thirty blocks and with far less annoyance to the householders than in the other cities. Invasions of the house, when occurring at all, being sporadic and only for a short time instead of lasting the greater part of the year. This result being attained at a total cost of about eleven hundred ($1100.00) dollars for three years. And now after over a year of no effort the ants are only beginning to make trouble.

In 1915 Berkeley again appropriated funds for control work, the present campaign being in charge of W. A. Gregory. The work attempted is purely control, no effort being made to force measures at any point, but wherever assistance is asked for, the city, through its health department, takes charge of the control measures and bears all expense. At the end of the present fiscal year, one hundred and sixteen out of one hundred and thirty-three infested blocks are being treated, the total cost for the year's campaign being sixteen hundred ($1600.00) dollars or about one dollar and twelve cents $(1.12) a block per month.

While the remedy has been available to all, and most of the drug stores in the infested districts manufacture it under the name of the Argentine Ant remedy but of course at a much higher price than the wholesale rates at which the municipality can furnish it, and while the University has given directions and sent circulars to all who are interested in control work, yet the ants continue to increase and many householders fail to find relief from the insect even though time and money are spent freely in the attempted control.

Some give up and move to uninfested localities, increased difficulty is found in retaining tenants in the districts, rents are lowered, and even realty values fall, not from the lack of spending money but because it has not been used properly. These results show that simple as the process is, the best results are secured when the municipality assumes the responsibility and places an expert in charge of the work.

1st. This shows in the more certain control since only a portion of the people have success with the remedy;

2d. The lessened cost,—much less, experience has shown than the community spends; and,

3d. The greater safety, since there will be no necessity of keeping a stock of the poison in the house.

The trustees of every city infested by the Argentine Ant can thus provide the means of avoiding the lowering of the value of their residence property due to the presence of this insect.

CHAIRMAN H. J. QUAYLE: This paper is now open to discussion.

DR. E. G. TITUS: In the paper read the date of the first collecting of the Argentine ant is given as 1908. I took it in the year 1905 at Ontario, Cal.

MR. H. S. SMITH: What influence has Argentine ant on the numbers of scale insects? Professor Lounsbury reports the black scale as a pest only after the appearance of the Argentine ant in South Africa?

CHAIRMAN H. J. QUAYLE: The soft brown becomes specially serious under its influence. The ants keep off the parasites and the absence of parasitism is noticeable in the case of this scale. It has not been noted, however, in connection with the black scale.

MR. H. S. SMITH: The Argentine ants cause the disappearance of ladybird beetles in breeding cages.

DR. E. G. TITUS: I saw the ants eating the eggs of ladybird beetles at New Orleans.

CHAIRMAN H. J. QUAYLE: The next paper has been prepared by J. G. Bridwell of Honolulu, H. T. and will be read by Mrs. Bridwell who has come for this purpose.

BREEDING FRUIT-FLY PARASITES IN THE HAWAIIAN ISLANDS

By J. G. BRIDWELL

Among the fruit-fly parasites brought to Honolulu by Professor Silvestri from Africa and Australia in 1913 for the Board of Agriculture and Forestry of Hawaii were three *Opiine Braconids* attacking maggots while in the fruit. Difficulties encountered in breeding these in captivity resulted in the loss of *Opius perproximus*. *Opius humilis* and *Diachasma tryoni* only were established in the Hawaiian Islands by liberating the parasites under tents over coffee trees in Kona, Hawaii, the tents being left upon the trees for about ten days and the fruit left undisturbed. It fell to the writer to handle material from which *Opius humilis* was later recovered. The material so recovered permitted experiments which established a successful method of breeding the species in captivity which has since facilitated the multiplication of *Opiine* parasites and the simple cage devised has proved adaptable

for several purposes besides. These experiments and others relating to the adaptability of the parasite to its host in various fruits were carried on in the latter part of 1913 and the early months of 1914. The writer's sudden and unforseen departure in June, 1914, for the west coast of Africa interrupted these experiments and has prevented an earlier report upon them.

At the time of Professor Silvestri's arrival in Honolulu in May, 1913, no method of breeding generation after generation of *Opiine Braconids* (or, indeed, other normally mating *Braconids*) in captivity had been worked out. Accordingly the material of the *Opiines*, *Opius humilis* and *Diachasma tryoni*, brought with him by Professor Silvestri, and those emerging soon after, were divided into two lots, one of which was retained in captivity for breeding and the other liberated by Mr. D. T. Fullaway, as previously mentioned, in the Kona coffee fields. The material of *Opius perproximus* was at the time, June 13, 1913, reduced to a single female and this was retained in the insectary.

Upon Professor Silvestri's departure the breeding work was carried on according to his plans by Mr. Fullaway and the writer, the work upon the *Opiines* falling to Mr. Fullaway. The methods employed were briefly as follows: The parasites, both sexes together, were kept in 6-inch test tubes and provided with food (honey and water) upon leaves. The tubes were kept in cardboard trays lying down and shaded and partially darkened by a covering paper. When it was desired to employ them in breeding, fruit was placed on dampened sand in tall, narrow jars placed on their sides with the bottoms toward the light. The parasites were permitted to escape from the tubes into the jars and remained there for some hours. The fruit and damp sand had a tendency to "sweat" the glass and great care was necessary to avoid the destruction of the parasites through their coming in contact with the wet glass. The fruit-fly puparia from fruit exposed to the parasites were kept with sand in shell vials of about 1-inch diameter until the parasites emerged with the flies. The net results of the use of this method were as follows:

Diachasma tryoni, 334, of which 19 from a single lot of puparia were females.

Opius humilis, 56, all males.

Opius perproximus, 17, all males.

The last emergences were on August 18 and upon the writer's taking up the direction of the breeding work on October 1, only a few lingering males of *D. tryoni* were in the insectary. From the areas in Kona where the *Opiine* parasites had been liberated June 13, small lots of coffee were brought into the insectary and on October 10 and 26 individuals of *Opius humilis* emerged from the puparia so secured. A

single female and 3 males from this lot were employed in a single experiment to test the writer's theory of the cause of the failure of the method previously employed.

The damp atmosphere of the fruit enclosed on damp sand in a jar and the resulting dew on the glass formed one obviously unfavorable environment for the delicate parasites. The absence of females, except in a single lot of puparia, suggested failure to secure proper mating and the production of males by parthenogenesis. Observation showed that males placed with females in tubes usually showed but little sexual excitement until exposed to strong light or sunlight. A tube containing both sexes when exposed to sunlight for a very short time became an animated scene and the males became highly excited, running about with their wings elevated and repeatedly attempted mating. In a test tube, however, the attempts at mating usually proved abortive and in only a very few instances was actual copulation observed.

It seemed then only necessary to expose the fruit to the parasites in a cage allowing free access to the air and perhaps a moment's exposure to the sunlight to start mating in a more favorable situation. The writer had just been reading of the success in breeding dipterous parasites of the gipsy moth in small wire cylinders and it occurred to him preferable to make his first attempt in such a cage. Accordingly he constructed a crude cylinder about 5 x 2½ inches and placed in it coffee berries infested with fruit-fly maggots, a single female and several males of the parasite, which he left for two days. From the resulting puparia ten parasites emerged, equally divided between the sexes.

A subsequent sending of the coffee berries from Kona gave ample material for breeding but for some months' time failed for further experiment, the work of editing the Silvestri report and seeing it through the press preventing further experiment at the time and for some months the parasites were bred exclusively by the tent method, the fruit from each tent being collected and the parasites bred out in the insectary. Subsequent experiments confirmed the impression of the conditions necessary for success and ultimately the following apparatus and method was adopted and put into use. In Africa, also, this cage was successful and upon his return in December, 1915, the method was still employed in the insectary.

It was desired to keep several males and females of the parasite with the fruit until decay compelled their removal to preserve them alive and recover them, to make the cage as light and airy as conveniently might be and to prevent the parasites getting away any considerable distance from the fruit or from their food. To prevent the parasites from becoming entangled and destroying themselves, it is necessary to have the cage within free from crevices into which they may pene-

trate in their efforts to escape. The cages finally adopted were made from ordinary nursery flats 16 x 12 x 3 inches. The flat, as made up, is used for the base of the cage. The cover, or as may be said, the cage itself, is made from the material used for the ends and sides of the flats, cut to make a frame fitting quite loosely into the flat and a top of fine copper wire cloth fastened on with wooden strips like the screen on screen doors.

A layer of dry sand is placed in the bottom of the box. A basket, made by bending up the edges of ¼-inch mesh wire screen, and fitting easily into the top, is filled with a single layer of the fruit employed. The test tubes containing the parasites and some leaves with honey and water dotted over them, are placed on the fruit. The cotton plugs are removed from the tubes to permit the escape of the parasites and the top is quickly put in place over the basket of fruit and pressed firmly down into the sand which effectually seals the cage and prevents the escape of parasites or the entrance of ants. The maggots emerging from the fruit cannot penetrate into the sand to any great depth. The wire basket prevents the fruit, wet from the oozing juices, from coming into contact with the sand and caking it so as to interfere with the sifting of the pupæ from it. When it is desired to remove the parasites this cage is opened in the insectary and after a time they will go to the window. The insectary of the Board of Agriculture and Forestry has a room admirably adapted for the purpose. For such use a room should have the following qualifications: It should be small, should have a shelf-table built in tightly against the base of the window occupying the side of the room above the table, in the northern hemisphere, with a northern exposure. There should be no other strong light and the interior should show no cracks or crevices and should be painted white. The ceiling should be everywhere in easy reach standing, a narrow shelf should extend around the room and ample ventilation can be provided with small openings covered with very fine mesh copper wire screening.

The method described is a practical one and permits the production of large numbers of parasites with facility but it has the disadvantage of not permitting observations to be made upon the actions of the parasites. Mr. C. R. Pemberton of the Federal Bureau of Entomology, who is at present engaged in a detailed study of the life-history of the *Opiine* fruit-fly parasites, and has already secured most interesting and valuable results from his work, has been able to secure partial mating and satisfactory oviposition by the use of the dried fruits in small quantities in glass. The mating seems to be more successful in the larger tubes he has used for the purpose.

A series of experiments were carried on in the spring of 1914 to

ascertain if *Opius humilis* would attack the fruit-fly in its various host fruits, employing tents in part and cages in part. The work carried on later by Dr. E. A. Back, of the Federal Bureau of Entomology, has confirmed the impression made by this preliminary series. No fruit adequately experimented with failed to produce parasites though in highly variable numbers. The rate of reproduction of the parasites was found to be somewhat greater with favorable conditions than that of the fruit-fly. The tentative conclusions then arrived at have required no modification as the result of the later work. It seemed then, as it does now, that under favorable conditions, from the thin meated fruits, such as coffee, terminalia and elengi, the parasites might well practically eliminate the fruit-fly but in the case of fleshy fruits, such as mango, guava, peach and chinese orange, the mechanical difficulty of parasitizing the maggots would prevent the parasite being any great factor.

As the result of three years' connection with the work on the fruit-fly in Hawaii, Africa and Australia, the writer is convinced that under Hawaiian conditions, the fruit-fly must be controlled by the use of parasites to reduce the flies to the point where the poisoned balls will be effective. The work done seems to make this conclusion certain. Under South African conditions, which simulate more closely those in California, it is quite certain that Mr. Mally has made as complete a commercial success of the poisoned bait method as is ordinarily obtained in economic entomology.

Secretary E. O. Essig: There are a number of applications for membership which should be signed and referred to the membership committee of the general association and for this purpose I move that the chair appoint a membership committee for this purpose.

This motion was duly seconded and passed.

Chairman H. J. Quayle: As this committee must consist entirely of active members it will be necessary for Dr. E. G. Titus and myself to act. The meeting is adjourned until tomorrow morning at 10 o'clock.

The meeting of August 11 was called to order by chairman H. J. Quayle at 10 o'clock. a. m.

Chairman H. J. Quayle: For the first thing we will have the report of the nominating committee.

REPORT OF THE NOMINATING COMMITTEE

The report of the nominating committee for the officers of the Pacific Slope Branch of the American Association of Economic Entomologists for the ensuing year is as follows:

For chairman, A. W. Morrill, Phœnix, Arizona.
For vice-chairman, R. A. Cooley, Bozeman, Mont.
For secretary-treasurer, E. O. Essig, Berkeley, Cal.

For the membership committee

One year, A. L. Melander, Pullman, Wash.
Two years, E. G. Titus, Logan, Utah.
Three years, H. J. Quayle, Riverside, Cal.

(Signed) E. G. Titus,
H. S. Smith.

This report was duly accepted by the members and the officers as nominated were declared elected.

Chairman H. J. Quayle: Is there any other business to come before the house at this time?

Dr. E. G. Titus: I wish to offer the following resolution:

Resolved, That we appreciate the use of the high school as a meeting place and express our sincere thanks to the City Board of Education for the use of the same.

This resolution was duly adopted by the house.

Chairman H. J. Quayle: We shall now take up the remainder of the papers. The first one this morning is by Mr. H. S. Smith.

AN ATTEMPT TO REDEFINE THE HOST RELATIONSHIPS EXHIBITED BY ENTOMOPHAGOUS INSECTS[1]

By Harry Scott Smith, *Superintendent California State Insectary, Sacramento, California*

In any field of endeavor it is desirable occasionally to review the past, making such readjustments as may seem necessary in order to provide a more secure basis for future work. In zoölogy the taxonomist accomplishes this by monographing, as necessity may demand, the group in which he is interested. The monographer performs a valuable service, since he not only standardizes that which has been done by others before him, placing each known species in its proper phylogenetic position in the group, but he defines the species as well and, if his results be worthy, makes it unnecessary for future students to go back of his monograph. In this way much valuable time is saved, and many needless misunderstandings, through lack of proper definition, are avoided.

In biological work names are quite as necessary as in taxonomy, and a careful definition of a biological phenomenon is fully as important as a correct description of a genus. Just as descriptions of genera must occasionally be altered as new species are made known, just so must the terms in biology occasionally be altered to keep pace with the advance of knowledge in biology. Definitions in a growing science

[1] Occasional contributions from the California State Insectary, No. 2.

are things to be modified and limited, just as the science itself is modified and limited.

The use of entomophagous insects in economic entomology, while not exactly a new branch of science, has experienced a considerable development in recent years. This development has necessitated more careful biological work on entomophagous insects, and has indirectly resulted in the adoption of a number of new terms to designate, among other things, the many different types of host-relationships exhibited. Many of the terms having to do with insect parasitism have "just growed." They have never been defined, and as they originated at a time when our knowledge of the subject was much less than at present, we find that they frequently include, under one name, two or more distinct phenomena. In other cases two or more terms have been used to designate the same phenomenon. The host-relationships of entomophagous insects is a subject of considerable complexity and an accurate definition of the different types is essential to a clear understanding of them. It has seemed to the writer that to redefine the old terms now in use, to standardize, in a way, the terminology of insect parasitism, would be to render a service to the workers in that branch of entomology. In the following pages will be found the writer's contribution, in so far as his limited knowledge of the subject will permit, to such a redefinition.

The term parasite itself is one of the most difficult to define and it will not be attempted here. In this paper, when the term parasite is used, it will be understood to refer to certain temporary entomophagous insects only, and not to those insects such as Mallophaga, etc., which depend upon animals other than Arthropods for their subsistence.

In recent years there have appeared two papers,[1] by Messrs. Fiske and Pierce, in which certain phenomena connected with host-relations were defined. These will be referred to frequently later on.

Parasitism and Predatism

The first and simplest division usually made of entomophagous insects is based on their method of feeding. These divisions are usually designated as parasitic insects and predaceous insects, and these terms are generally used in what seems to be the correct sense. A parasitic insect, in the generally accepted sense, is one which passes its entire larval state within or upon a single individual host. A

[1] Fiske, W. F.: Superparasitism: An Important Factor in the Natural Control of Insects, Jour. Econ. Ent., vol. III, pp. 88–97; Pierce, W. D.: On Some Phases of Parasitism displayed by Insect Enemies of Weevils, Jour. Econ. Ent., vol. III, pp. 451-458.

predaceous insect is one which requires more than a single individual of the host species for completing its development and this requirement would seem to necessitate a more or less well developed means of locomotion. There is, however, no definite division between parasitism and predatism and in certain cases it is difficult to know whether to call an insect a parasite or a predator. A case of this kind is the Pteromalid scale-parasite *Scutellista cyanea*. If we follow the definition given above *Scutellista* might come in either the parasitic or predaceous category. The female Scutellista deposits her eggs beneath the adult black scale. The parasite larva, however, feeds upon the eggs of the host and requires a large number, frequently several hundred, to complete its development, although it always matures beneath and upon the eggs of a single host scale. The question then arises as to whether we should call Scutellista a parasite of the black scale or a predator upon black scale eggs. The definition of the term parasite might be enlarged to fit cases of this kind by saying that a parasite is an entomophagous insect which requires but a single individual host insect, or the eggs of a single individual, to complete its development. But in calling to mind the life-histories of various kinds of parasites we find that even this enlargement of the definition as generally understood will not serve to define the host-relations in all cases. *Macrorileyia œcanthi* Ashm., a Chalcidoid parasite (?) of the tree-crickets, carries us a step farther. This so-called parasite lives in the pith of the twigs in which the tree-crickets have deposited their eggs and upon which it feeds. Unlike Scutellista, however, it may, and frequently does, feed upon the eggs of more than one individual tree-cricket, and by reason of this approaches still more closely to predatism. There are many examples of this type of host-relations. In Italy there occur two Chalcidoid enemies of the alfalfa weevil, one a Pteromalid and the other an Eupelmine, of similar habits. The eggs of the alfalfa weevil and other species of Phytonomus are deposited within the stems of the host-plant in clusters. The two parasites mentioned here feed upon these eggs not as egg-parasites but as predators, often devouring egg-masses from several different weevils. Excepting for the fact that one is protected and the other feeds in the open, there is no essential difference between these so-called parasites and the larva of Leucopis, for example, which feeds upon the eggs of mealy-bugs, or the larva of the Brown Lacewing, Hemerobius, which feeds upon the eggs of the same host. Scymnus, Hyperaspis and many other ladybirds have similar habits. In view of these facts, therefore, we can scarcely say that there is a definite line of demarcation between parasitism and predatism, but the two, like geographic races, intergrade, the two extremes being quite distinct. In fact there

are some species of insects, like *Aphelinus mytilaspidis*, for example, which are both predaceous and parasitic, feeding either upon the adult insect, or the progeny beneath the parent insect. The distinction between parasitism and predatism is of no great importance, but it is well to bear in mind that many of the so-called parasites are parasites only because they belong to a parasitic group, and not by reason of their method of feeding.

The interrelations of the parasites themselves are quite complex and, it seems to the writer, not as yet well defined. A knowledge of these interrelations is of not a little importance when the subject of the control of noxious insects by their insect enemies is under consideration. There have been used in the past a number of phrases and terms to designate the different kinds or types of host-relations and of interrelations of the parasites themselves, many of them used in one sense by one author and in an entirely different sense by another. Obviously this is not conducive to a clear understanding of the subject and should if possible be avoided. Some of these terms and phrases are hyperparasitism, secondary parasitism, tertiary parasitism, superparasitism, accidental secondary parasitism, cannibal superparasitism, mixed superparasitism, true secondary parasitism, multiple parasitism, etc.

Hyperparasitism

The term hyperparasitism is generally used to denote any stage of parasitism other than primary. That is, either a secondary parasite or a tertiary parasite is a hyperparasite. This is a useful term in the entomological vocabulary and is generally confined to the above meaning, although some use it synonymously with "secondary." Misuse of the term occasionally occurs when, for example, parasites of ladybirds are called hyperparasites. There is certainly no valid excuse for calling a parasite of ladybirds a hyperparasite, since it is not a parasite of a parasite, but is simply a primary parasite of Coccinellidæ. The fact that ladybirds are usually beneficial should have no bearing in the case, and such use of the term is only confusing. Neither should primary parasites of any other predaceous insects such as Leucopis, Chrysopa, Syrphus, etc., be called hyperparasites, although we find such use of the term occasionally in entomological literature.

Indirect Parasitism

Indirect parasitism, which is a type of hyperparasitism, is most closely related to secondary parasitism, and has not heretofore been defined. This type of host-relationship can best be illustrated by examples. One of the most noteworthy instances of this type is the Chal-

cidoid parasite *Perilampus hyalinus*,[1] and is, so far as I know, the first case on record of an indirect parasite. *Perilampus hyalinus* has an hiatus in its known life-history, since we know nothing at the present time of its oviposition habits. But we do know that it attacks the larvæ of *Hyphantria cunea*, not for the purpose of breeding upon Hyphantria, as it is unable to do this, but for the sake of the primary parasite which it harbors. Strangely enough, in the case of this particular parasite, it does not matter much what the primary parasite is, just so it is an internal parasite of *H. cunea*. It will be seen then that in the type of host-relationship known as indirect parasitism there are always three insects necessarily concerned simultaneously if the indirect parasite is to succeed in reproducing: first, the host of the primary parasite; second, the primary parasite, and third, the indirect parasite. No other host conditions will suffice. It will readily be seen that this type of host-relationship represents a very different kind of parasitism from that occurring where a parasite oviposits directly into the primary and yet both have always been known as secondary parasitism. Types of host-relationship so widely different should be distinguished by different terms. I would restrict the term indirect parasitism to the type of symbiosis similar in a general way to that occurring in *Perilampus hyalinus*. As a definition of indirect parasitism I would suggest the following: *Indirect parasitism* is that type of symbiosis in which the one parasite attacks a host insect upon which it itself is incapable of breeding, for the sake of the primary parasite which it may harbor. Since the biology of so few parasitic insects is known it is impossible to say just to what extent indirect parasitism occurs in nature. Besides *Perilampus hyalinus* one or two other species of this genus are known to have this habit, although several species are known to be true primary parasites. In the Ichneumonoidea this type of parasitism is known to occur in *Mesochorus pallipes*, a parasite of the Braconid, *Apanteles fulvipes*, which is in turn a parasite of the gypsy moth in Europe. Since several other species of this genus are parasitic on Apanteles species, it is probable that many of them have the same habit. To this class belong also a number of hyperparasites of scale insects. Among them are species of the genus Eusemion which are parasites of Microterys and Aphycus, in their turn parasites of the soft brown scale, species of Cheiloneurus which breed on various parasites of mealy-bugs and scales, and Cerchysius, a parasite in one case of Microterys on soft brown scale, and in another on *Scutellista cyanea* and *Tomocera californica*, parasites of the black scale.[2] Species

[1] The Chalcidoid Genus Perilampus, and its Relations to the Problem of Parasite Introduction. Bul. 19, Tech. Ser., pt. IV, Bur. Ent., U.S.D.A.

[2] *Vide* Timberlake, "Parasites of Coccus hesperidum," JOUR. ECON. ENT., vol. 6, pp. 293-303.

of Figitidæ also have this habit, ovipositing into aphids in order to breed upon the aphidiines infesting them. Considered from an economic standpoint, these indirect parasites are of no greater importance, are capable of no greater harm, than are the other hyperparasites. In fact they are less to be feared as a general rule since their life-histories are more complex and the more complex an insect's life-history is, other things being equal, the less possibility there is of its becoming abundant.

Secondary Parasitism

The type of host-relationship most closely allied to indirect parasitism, and most generally confused with it, is secondary parasitism. While these two forms of symbiosis bring about the same final result, *i. e.*, the destruction of the primary parasite, the manner of accomplishing this end is very different. Strictly speaking, a secondary parasite is merely a primary parasite of a primary parasite. While this is also true of the indirect parasite, they differ in that the adult of the indirect parasite does not oviposit directly in or upon its host, but into or upon the host of the primary.[1] The adult of the secondary parasite deposits its eggs directly into or upon the body of the young primary. The life-history of the true secondary is very simple as compared to the complex life-history of the indirect parasite. In the one case two insects only, the secondary and its host the primary, are concerned. In the other three insects, the indirect parasite, the primary parasite and the host of the primary are all directly concerned.

True secondary parasitism is of very common occurrence in nature, and is of great importance in the natural control of insects. Practically all species of primary hymenopterous parasites, and especially the cocoon-forming groups of which the Ichneumonoidea compose the majority, are greatly subject to attack by these insects. The Tachinidæ and other parasitic Diptera are also destroyed in large numbers. True secondary parasitism is of most common occurrence among the Chalcidoidea and is found especially in the families Eulophidæ and Pteromalidæ. It also occurs in the Eurytomidæ, Elasmidæ, Callimomidæ and Chalcididæ. It occurs very uncommonly, if at all, in the Encyrtidæ, since in that highly specialized family indirect parasitism takes the place of secondary parasitism. I do not call to mind at this time any case of secondary parasitism, as here defined, in the Proctotrypoidea or Cynipoidea, although in the latter indirect parasitism occasionally occurs. Secondary parasitism should occur in both of these superfamilies, however, since many species are parasites of Diptera and they will undoubtedly be found to attack some of the

[1] In the case of *Perilampus hyalinus*, the oviposition habits are unknown, but the young parasite larva or *planidium* is first found on the outside of the caterpillar.

parasitic species.[1] In the Ichneumonoidea secondary parasitism occasionally occurs, especially in the Cryptinæ.

As a definition I would suggest the following: Secondary parasitism is that type of symbiosis where a parasite destroys a primary parasite by direct attack, and not through the medium of the host of the primary parasite.

Since this type of insect has the same relation to primary parasites as the latter have to insect pests, it naturally follows that they are an extremely important consideration in the control of injurious insects. They are in our native fauna responsible in many cases for the ineffective work of primary parasites which would otherwise be of great practical value. In the introduction of new beneficial insects it is obviously of greatest importance to guard against the introduction of these secondaries. Many primary parasites of little importance in their native habitat might, by introducing them into new localities, become of great practical value through the elimination of their secondaries, especially if these secondaries have no counterpart in the new locality. Occasionally, however, the newly introduced parasite is immediately attacked by secondaries native to the new locality and which had as their original host species of the same genus as the parasite introduced. A noteworthy instance of this kind occurred at the Gypsy Moth Parasite Laboratory of the U. S. Department of Agriculture.[2] *Apanteles fulvipes*, a common parasite of the gypsy moth in Europe and Japan, was introduced as a most promising species. In Europe it was found to be attacked by something like twenty-five species of secondaries and indirect parasites, and other hyperparasites. In Japan at least thirty species of hyperparasites occurred. During the first generation on American soil seventeen species of hyperparasites, for the most part different species but the same genera as those occurring in Europe and Japan, attacked *Apanteles fulvipes*.

In this case the elimination of the secondaries probably did not have a very important bearing on the success of the introduction, since the introduction of hyperparasites having the same habits as native parasites would merely serve to eliminate to a large degree the native hyperparasites, leaving the total percentage of mortality about the same as before. The introduction of secondaries which have no counterpart in the new fauna, however, would have an entirely different effect and the greatest care should be exercised to eliminate any hyperparasites which would form a new element in the local fauna. Obviously the only safe way of doing this is to eliminate them all.

[1] Since writing the above I have come across a record of true secondary parasitism among the Proctotrypoidea by Mr. Swezey of the Sugar Planters' Station of Honolulu. A species of *Ceraphron* was found to parasitize *Haplogonatopus*, a Dryinid.

[2] Howard and Fiske: Bul. 91, Bur. Ent., U.S.D.A.

Tertiary and Quaternary Parasitism

Parasitism of a stage beyond that of secondary—if we disregard those cases of accidental or chance parasitism—is of not at all common occurrence. I do not at this moment recall a single authentic case of true quarternary parasitism, although such have been recorded. It will generally be found in the instances where parasites are recorded as quaternary that they are only accidentally so, the same species being by nature either secondary or tertiary. Some parasites such as *Dibrachys boucheanus* are so omnivorous in their food habits that they will develop on practically any parasite larvæ enclosed in a cocoon or puparium. This being the case, if they oviposit into a cocoon containing larvæ of a tertiary parasite they are able to develop on the tertiary larvæ and then they become numerically speaking quaternary parasites. They are not, however, obligatory in this rôle, and if they are to be designated as quaternary at all the term should be modified by the word accidental. There are grave doubts as to whether an obligatory quaternary parasitic insect exists.

Obligatory tertiary parasitism does exist in nature and will no doubt be found to be a fairly common phenomenon when the life-histories of more parasitic insects are thoroughly known. The best instance of true tertiary parasitism is that of the Eulophid, *Asecodes albitarsis*. The writer has made hundreds of dissections of cocoons of various microgasterine parasites in New England and in every case Asecodes was found to be a true tertiary parasite, breeding generally upon *Dibrachys boucheanus*, a true secondary. Other species of the Entedonini will without doubt be found to belong to this category.

Dr. L. O. Howard in his interesting paper on the parasites of the Tussock moth, at the close of his chapter on the interrelations of the parasites, says: "We would naturally have expected a period of abundance of tertiary parasites to have followed that of the secondary parasites. This, however, was not the case. Tertiary parasitism seemed to be comparatively rare and was only definitely proven in the case of *Asecodes albitarsis* and *Dibrachys boucheanus*, the latter being usually a secondary parasite. . . . There must be a limit to this work of parasite upon parasite at some point and it seems certain that tertiary parasitism is rare and that quaternary parasitism seldom occurs."

As mentioned above, Dibrachys is in reality a secondary and becomes tertiary in this case only through accident and its omnivorous food habit. Asecodes is, however, an obligatory tertiary parasite. I would define then as tertiary parasitism that type of symbiosis where a parasite is obligatory upon an obligatory secondary. A true quaternary would necessarily be obligatory upon an obligatory tertiary parasite. I believe with Dr. Howard that there must be a limit

to this work of parasite upon parasite and while it is perhaps unscientific to allow one's opinions to outstrip the facts, especially when so few life-histories of parasites are known, I doubt if true quaternary parasitism as defined above really exists among entomophagous insects. Accidental quaternary parasitism does of course occur in the case of omnivorous or general feeders such as Dibrachys or Melittobia and so far as this type of insects is concerned there is practically no limit to the numerical relations which may develop. Dibrachys will, for example, breed upon Asecodes and in its turn Asecodes will breed upon this generation of Dibrachys, and while this sort of thing can hardly go on *ad infinitum* as Burns would have us believe, it would certainly continue as long as the food supply lasts.

Superparasitism and Multiple Parasitism

Superparasitism has been defined by Fiske (*loc. cit.*) as that form of symbiosis resulting "when any individual host is attacked by two or more species of primary parasites or by one species more than once." We have under superparasitism as defined by Fiske two quite distinct phenomena. These were later designated by Pierce (*loc. cit.*) as cannibal superparasitism and mixed superparasitism. In a previous article Mr. Pierce gave to the latter phase of parasitism the term accidental secondary parasitism. This phase or rather these phases of parasitism have been so ably treated by the two entomologists mentioned, that there remains little to be said in this connection and those interested are referred to the two articles for further information. However, since the avowed purpose of this paper is to standardize the terminology of the host relations of entomophagous insects the subject cannot logically be left with two terms for the one phenomenon in one case and one term for two phenomena in the other.

The writer would suggest that the term superparasitism be restricted to those cases where there is a superabundance of parasites *of a single species* (cannibal superparasitism of Pierce). It frequently happens, especially when the total percentage of parasitism runs abnormally high, that the mother parasite deposits many more eggs than can possibly reach maturity on a single individual host, or in other cases, after one female parasite has laid her quota of eggs another female of the same species, lacking the ability to distinguish between parasitized and unparasitized hosts, deposits a further supply in the same individual. This phenomenon alone I would term superparasitism, leaving the other phase included in Fiske's superparasitism to be termed multiple parasitism (Pierce's accidental secondary parasitism and mixed superparasitism).

By way of definition I would suggest the following: Superparasitism

is that form of symbiosis occurring when there is a superabundance of parasites *of a single species* attacking an individual host insect. Multiple parasitism is that form of symbiosis where the same individual host insect is infested simultaneously with the young of *two or more different species* of primary parasites. The term multiple parasitism has already been used by Pierce to designate gregarious parasites and while I dislike to use the same term for a different phenomenon I know of no unused expression which fits so well this phase of parasitism.

In a brief paper like this it is possible only to touch upon the main headings of the extensive subject of host-relationship of entomophagous insects. It has been attempted to define only the most important divisions, but each of those is of course divisible into a number of lesser types. While the writer is not so rash as to believe that there will be a general acceptance of these definitions by entomologists, he does hope that they will be of some assistance to students of this most interesting phase of biology.

CHAIRMAN H. J. QUAYLE: The next paper will be on the dispersion of scale insects by the wind.

DISPERSION OF SCALE INSECTS BY THE WIND[1]

By H. J. QUAYLE, *University of California, Citrus Experiment Station, Riverside, California*

The manner and extent of dispersal of many insects have been largely conjectural until recent years, and even now exact data have been secured for comparatively few species. Of course, we have had records of the great distances that certain flying insects may travel. It is only necessary in this connection to mention such insects as the migratory locust, *Schistocerca peregrina*, which has been found five hundred miles east of its home in South America and is supposed to have crossed over even to Africa, or our own Rocky Mountain locust, which has gone one thousand miles from its breeding ground, or certain moths that have been seen over four hundred miles at sea.

It is only recently, however, that we have come into possession of definite data as to how far such flying insects as the house-fly or such non-flying forms as gipsy moth larvæ may travel. Without authentic data, a few hundred feet or a few hundred yards was thought to be the limit of travel of the house-fly. The work of Arnold, Copeman, et al.

[1] Paper No. 36, Citrus Experiment Station, College of Agriculture, University of California, Riverside, California.

Hewitt, Hine, Howard, Hodge, Hindle, Zetek, and Parker, however, has given us positive data as to the dispersal of the house-fly, *Musca domestica*.[1] Parker has given us evidence for the greatest range of dispersion, namely, 3,500 yards, but this distance, as he infers, does not represent the possible extreme spread, because his captures were not beyond the distance indicated.

Burgess[2] and Collins[3] have determined that the gipsy moth larvæ may be carried by the wind for a distance of thirteen and one-half miles. Munger, Stabler,[4] and Weldon have shown that the almond mite, *Bryobia pratense*, may be carried by the wind a distance of 650 feet and to an elevation of 50 feet. This definite information concerning the agency of the wind in spreading insects has a very important bearing on any control measures that may be employed. The question, of course, is not so pertinent for insects that are controlled by an arsenical spray because the protective poison is present on the plant, and it makes little difference whether the insect comes from an adjoining tree or from a neighboring orchard.

In the citrus sections of California, where more regulation and enforcement of insect control are probably practiced than in any other part of the world, the matter of neighboring groves serving as a source for reinfesting treated ones is a question of considerable importance. Our previous work[5] has shown that there is little possibility of a young scale insect making its way from one tree to another by its own powers of locomotion. It has also been shown that insects and birds, as well as man in his usual cultural operations, may be factors in spreading the scales, and these agencies may account for the origin of an infestation at a considerable distance. But more important, we believe, than all of the above agencies in distributing scale insects, is the wind. While many of our horticultural officers have appreciated the importance of the spread of the scales from adjoining groves, the question has been doubted by some entomologists. It was for the purpose of securing, if possible, some definite data that experiments were undertaken along this line.

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[1] See JOUR. ECON. ENT., vol. 9, no. 3, p. 353, 1916, for these references.

[2] Burgess, A. F. The Dispersion of the Gipsy Moth. Bul. 119, Bur. Ent. U. S. D. A., 1913.

[3] Collins, C. W. Dispersion of Gipsy Moth Larvæ by the Wind. Bul. 273, Bur. Ent. U. S. D. A., 1915.

[4] Stabler, H. P. Red Spiders Spread by the Wind. The Monthly Bulletin, Cal. State Com. Hort. II: 12, p. 777, 1913.

[5] Quayle, H. J. The Red Scale. Cal. Exp. Sta. Bul., p. 129-131, 1911. The Black Scale. Cal. Exp. Sta. Bul., p. 160-165, 1911. The Purple Scale. Cal. Exp. Sta. Bul., p. 330-332, 1912. Locomotion of Certain Young Scale Insects. JOUR. ECON. ENT., vol. 4, no. 3, p. 301, 1911.

The first series of experiments was to determine to what extent the young of the black scale, *Saissetia oleæ,* might be captured on tanglefoot flypaper. After the paper had been exposed to the sun for two or three days, it was found that the sticky material became very hard and firm. It was at first thought that this fact would make the paper of little value for entangling the scales, but upon examination, it was seen that many were captured nevertheless. It should be noted, however, that in the discussion that follows, all time records are for but two or three days, the limit of effectiveness of the material, regardless of how long the sheets might have been exposed. If the tanglefoot had remained effective longer, there would, of course, have been many more scales captured. On the other hand, there is some little advantage in the handling and examination of the sheets occasioned by the hardening of the material. The sheets were placed in different situations and at different distances from infested trees as indicated below.

The Capture of Young Black Scale on Tanglefoot Sheets

Sheet No.	Exposure	Height	Distance	Date Placed, 1915	No. of Scales
1	South	5 feet	30 feet	June 28	146
2	West	2 "	30 "	" 28	360
3	East	2 "	30 "	" 28	156
4	North	5 "	30 "	" 28	228
5	North	6 "	30 "	" 28	192
6	South	5 "	30 "	" 28	96
7	East	5 "	Center tree sq.	" 28	84
8	West	3 "	Ibid.	" 28	504
9	West	3 "	35 feet	" 28	168
10	West	3 "	35 "	" 28	300
11	West	3½ "	45 "	" 28	432
12	West	3½ "	Center tree sq.	" 28	831
13	West	3½ "	Ibid.	" 28	1056
14	West	3½ "	20 feet	" 28	147
15	West	3½ "	35 "	" 28	228
16	West	4 "	13 "	" 28	840
17	East	4 "	27 "	" 28	246
18	West	3 "	100 "	" 28	523
19	West	3 "	200 "	" 28	361
20	West	3 "	250 "	" 28	93
21	West	5 "	450 "	" 28	31
22	West	3 "	Center tree sq.	Sept. 1	2
23	West	3 "	Front of tree	" 1	4
24	West	3 "	Ibid.	" 1	1
25	West	3 "	Center tree sq.	" 1	3

The twenty-one sheets put out on June 28, 1915, entrapped a total of 7,262 scales or an average of 346 scales for each sheet. Only four sheets fell below 100, while the maximum number was 1,056. The distance from the infested trees ranged from 10 feet to 450 feet, the average distance being 70 feet. The prevailing direction of the wind was from the west and southwest. On the sheets facing west, the average for each sheet was 408. On those with a south exposure, the average was 241, north exposure, 210, and east exposure, 162. However, because of the difference in the number of sheets with the differ-

ent exposures, and the fact that infested trees occurred on more than one side in some cases, no definite conclusions are drawn from the above figures as to the number of scales captured in relation to the prevailing direction of the wind.

In the case of the black scale, which has a more or less definite annual period of young production, dispersal would be expected to occur largely during that period. The only other time would be when the scales are migrating from the leaves to the twigs, or when they have detached themselves from the plant for any other reason, and at such times, on account of the increased size of the insects, their dispersal by the wind would not be so great.

The above conclusions are supported by our experiments as shown by the last four sheets referred to in the table. These sheets were exposed on September 1, after the hatching of the scales had ceased, and they were settled on the leaves and twigs. The sheets were placed in the same grove as those of June 28, and 15 feet was the greatest distance away from infested trees. The average number captured on these sheets was 2½ scales as against an average of 346 scales on the sheets placed on June 28. The important period of dispersal of the black scale, as well as of the citricola scale and others having usually but one generation a year, is, therefore, from April to September, or the period when the great majority of active young appear. This fact would not apply so strictly to scales having three or four generations a year, as the red, yellow, purple, and soft brown scales, since young may be present in greater or lesser numbers throughout the warmer portion of the year, or from March to December in California.

The data thus far secured have reference to the black scale, but Mr. Bishop of Orange County and his inspector, Mr. Paddock, had tanglefoot sheets so placed as to capture the red scale, *Chrysomphalus aurantii*. These sheets were submitted to the writer for examination. The distance ranged from 6 feet to 150 feet, and young red scales were found on most of the sheets.

In the experiments with the tanglefoot paper noted above, there was no obstacle between the sheets and the infested trees to interfere with the free carrying of the scales. In order to determine what happens under normal conditions in the grove, the following experiment was carried out:

A four-acre block of grapefruit was selected that was fumigated in 1914 with the result that practically 100 per cent of the black scale were killed. A careful examination of the block in April, 1915, resulted in finding no scales, and in midsummer all of the scales present were young scales indicating that they had not come from parent scales on the same trees, but from neighboring trees. This block of clean

trees was surrounded by severely infested orange trees on the west, south, and east sides. On the north was an abrupt slope of barren ground. There were 25 trees north and south and 16 trees east and west in the block. The examination for scales was made on August 20, 1915. Twenty-five leaves were selected at random from the north, east, south, and west sides of the tree respectively, making a total of 100 leaves from each tree.

Below is represented the block of trees on which examination of

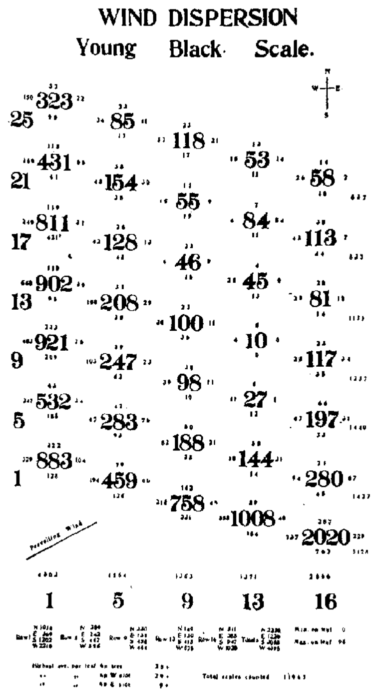


Fig. 35. Data from experimental plot. (Original).

young scales was made. The small figures represent the number of scales on 25 leaves on the respective sides of the tree, while the large number, which is the total of the small numbers, represents the number of scales on 100 leaves of the respective trees.

From the above it will be seen that there is a total of 4,803 scales on 100 leaves of every fourth tree on the west row, while the fifth row to the east drops down to 1,564 scales, or a difference of 3,239. The first

row on the south side shows 5,128 scales as against 1,427, or a difference of 3,701 on the fifth row from the infested trees. Taking the first row on the west again, there is a total of 2,218 scales on the 25 leaves on the west side of every fifth tree, as against but 369 scales on the same number of leaves on the east side of the same trees. The prevailing direction of the wind, it will be noted, was from the southwest.

This four-acre block, as the results have shown, was not large enough to determine all the possibilities of the experiment. It was scarcely anticipated that the scales would have spread over the entire area in one season, and since the infested trees were on three sides with a slight wind blowing from the opposite direction at night, as compared with that of the day, there appears to have been some movement from this direction. However, on the east row of the block, immediately adjoining infested trees, there are more scales on the west side of the trees than on the east side. The figures are 1,020 for the west side and 388 for the east side. With a few exceptions, all of the trees show more scales on the west than on the east side of the tree. On tree 13 in row 1, for example, 660 scales are found on the 25 leaves on the west side as against 36 scales on the same number of leaves on the east side.

From a practical point of view the agency of the wind in spreading plant-feeding or disease-bearing insects is of very great consequence. In the case of the block of trees referred to, the work of fumigation in 1914 was so satisfactory that the trees should have gone several years without treatment. As it was, in spite of the fact that 100 per cent of the scales were killed, the trees could not go untreated over a single year and had to be fumigated in 1915. Other host plants growing in the vicinity, particularly border host trees, are, likewise, directly responsible for reinfesting treated trees.

During the present season we varied our experiments on wind dispersal somewhat by having more direct control of the origin of spread. This was done by cutting branches, badly infested with the black scale, and suspending them on a pole in the midst of barren ground. Three tanglefoot sheets were placed in the form of arcs of circles at distances of 26, 46, and 70 yards respectively on the leeward side of the infested branches. The length of the inner arc was about 15 yards and of the outer arc about 45 yards. Three sheets were also placed on the windward side at a distance of 15 yards from the infested branches. A total of 60 young black scales were captured on the nine sheets on the leeward side, and none on the three sheets on the windward side. The maximum number on a single sheet, 24, was found on the one directly in front of the point of origin. The total of the three sheets in this arc, a distance of 26 yards, was 37 scales. The total on the next three

sheets in the next arc, a distance of 46 yards, was 17 scales, and on the next arc, a distance of 70 yards, 9 scales. All of these 60 scales came from an amount of branches that would be represented by a three- or four-year-old tree. On the three sheets on the windward side, but 15 yards distant, there were no scales.

Summary

Young black scale, *Saissetia oleæ*, have been found to be carried by the wind, as represented by their capture on tanglefoot sheets, at different distances up to 450 feet. This distance does not necessarily represent the extreme dispersal since provision for capture was not made beyond 450 feet.

The young of the red scale (*Chrysomphalus aurantii*) were captured on tanglefoot sheets at distances ranging from 30 to 150 feet.

It is possible that many of the scales on these sheets were dead at the time of capture, but that there were many alive is shown by the next statement.

Young black scale were distributed over an entire four-acre block of trees, without question chiefly by the wind, in a single season. They may be distributed by the wind over a much greater area than this.

That the spread is chiefly in the direction of the prevailing wind is shown from the figures given for the block of trees, as well as by the captures on the tanglefoot paper.

In the case of young black scale, dispersion by the wind occurs largely during the period of young production from April to September. With scales having three or four generations a year, the young producing period is prolonged and consequently the liability of the young to be carried by the wind is prolonged.

The data presented on the dispersion of scale insects by the wind, which data represent only a preliminary report, emphasize the practical importance of carrying on fumigation work solidly over as large an area as possible.

H. S. Smith: Were the scales experimented with young newly hatched larvæ or older forms?

Chairman H. J. Quayle: They were newly hatched larvæ.

D. L. Crawford: Which is the most responsible for the spread of scale insects, wind, insects or birds?

Chairman H. J. Quayle: Wind by far; birds and insects are very small factors.

Dr. E. G. Titus: I have found that the wind will carry young thrips at a height of 20 feet.

E. L. Prizer: Are birds and insects more likely to carry mealybugs than wind?

CHAIRMAN H. J. QUAYLE: The mealy-bugs are probably more influenced by the wind.

L. P. ROCKWOOD: Are wind barriers of any use in preventing the spread?

CHAIRMAN H. J. QUAYLE: Yes, but they might have to be very high as red spiders have been caught on a tank tower 50 feet high.

The next paper will be presented by Mr. L. P. Rockwood.

SPOROTRICHUM GLOBULIFERUM SPEG., A NATURAL ENEMY OF THE ALFALFA WEEVIL

By L. P. ROCKWOOD, *U. S. Bureau of Entomology, Forest Grove, Oregon*

The parasitism of insects by the fungus known at present as *Sporotrichum globuliferum* Spegazzini, although at one time seriously questioned and even denied by eminent mycologists, is now generally acknowledged. That this fungus is probably the most efficient natural enemy of the chinch bug, *Blissus leucopterus*, under conditions favorable for its growth and spread, is well known. However, very little data has appeared as to the occurrence of the fungus as a natural enemy of insects other than the chinch bug. We have long lists of insects of various orders recorded as furnishing a sub-stratum for the growth of this fungus, but few or no observations of the fungus as a factor in the natural control of these insects.

This fungus has come under my observation in connection with various insect hosts both in the field and laboratory at various times during the past two years. Its relation to the alfalfa weevil, *Hypera variabilis (posticus)* Hbst., in Utah in 1914, is dealt with briefly in this paper.

OCCURRENCE OF THE FUNGUS ON THE ALFALFA WEEVIL

The fungus *Sporotrichum globuliferum* Speg., was first found on the alfalfa weevil near Salt Lake City, Utah, on March 14, 1914. It was frequently met with and could easily be found on weevils and other insects under alfalfa plants from that time until May. This was a time of considerable precipitation and the ground in alfalfa fields was moist to wet most of the time. The time of greatest abundance of the fungus was April 21 to 29. At this time at least one weevil killed by the fungus could be found under almost every plant examined. On April 29 this was particularly true. On this date 11 weevils killed by the fungus were found under one alfalfa plant covering an area of about four square feet on a high bank outside the irrigated area.

This early mortality of weevils caused by *Sporotrichum globuliferum* is undoubtedly of considerable importance as the death of the adults

at this time, before and during oviposition, helps to reduce the destructive new generation of larvæ. No other natural enemy of like importance was observed at this season. In the early spring, the optimum conditions for the growth of the fungus are likely to be found in all the alfalfa fields on the East Bench of old Lake Bonneville regardless of the irrigation practice. The ground-frequenting habits of the weevils at this time, the season of mating on the ground under the early low growth of alfalfa, especially expose them to infection by frequent contact with the bodies of insects covered with the spores of the fungus.

Later in the season when the spring rains have ceased, the fungus seems to be restricted to fields which are generously irrigated and have a heavy close stand of alfalfa. One such field was examined on July 29 and 28 weevils with a pure growth of *Sporotrichum* were picked up in a short time. Such mortality at this late date is of slight importance, however, as this is the time when the over-wintered adults are dying off naturally. Yet it is worthy of note that this field for which a generous water supply was available and which was therefore lavishly irrigated has never been seriously injured by the weevil; at least so the rancher informed me, and I was inclined to believe him as it was certainly unusual for a Utah farmer to deny injury from the weevil. The fungus was observed in this field in abundance on September 10. Other insects killed by the fungus, notably *Sitones* sp., were also abundant in this field.

A spontaneous outbreak of the disease occurred among weevils of the new generation in a rearing cage at the laboratory about November 17 and caused a high mortality. Many weevils also died of the disease in an outdoor hibernation cage during the fall and early spring.

The Fungus

The fungus on *Hypera variabilis* (*posticus*) Hbst. was determined as *Sporotrichum globuliferum* Speg. by Dr. Flora W. Patterson, Mycologist of the Bureau of Plant Industry, U. S. Dept. of Agriculture.

The fungus is probably distributed over all of the Americas and has been recorded as found on the bodies of insects of several orders.

The macroscopic appearance of the fungus on weevils varies with the conditions under which the exterior growth of the fungus developed. In a confined dark cage with little or no ventilation, the fungus usually completely envelops the weevils in a loose, fluffy, cottony growth of fungus mycelium in the outer strands of which the scattered balls of spores are developed, the balls being usually separated from each other by an appreciable distance. Weevils partially buried in moist locations in the débris under alfalfa plants in the field also often

show this fluffy, cottony growth which sometimes spreads out over the rotting débris to an area of one half inch or more. Under the usual field conditions or in well ventilated, well lighted cages, the fungus forms a dense felted mass, usually confined to the elytral, thoracic, and abdominal sutures, which are often completely outlined by the white bands of the fungus mycelium. Upon this short felted growth of mycelium, the balls of spores appear densely packed together. Old specimens of the fungus assume a well-defined cream color.

It was found by experimentation that the macroscopic appearance of the fungus on weevils killed by mechanical or chemical means before exposure to the fungus presented a relatively different appearance from that on weevils killed by the fungus. In the case of weevils killed before infection, the fungus appeared as a very thin, long, loose, cottony covering, almost cloudy in appearance, nowhere localized in a thick mass. Moreover, in all such cases, contamination of the typical fungus with the well known saprophytic fungi of the genera *Penicillium* and *Mucor* invariably occurred under the somewhat septic conditions incident to the experiment. Weevils killed by the fungus always developed a pure dense growth of the typical fungus, and saprophytic fungi never developed upon them until after the parasitic fungus had matured and disintegrated. Weevils killed by the fungus are usually found in a life-like attitude with legs and antennæ extended as if death overtook them suddenly while on the move.

Laboratory Experiments

No cultures of the fungus in artificial media were attempted. Spore germination studies by the hanging drop method in Van Tieghem cells were made for the purpose of gaining information for the better interpretation of dissections and blood examinations. The formation of the so-called "cylinder-gonidia" of DeBary[1] were thus studied and later identified in the blood of infected weevils.

Several infection experiments with *S. globuliferum* on *H. variabilis* (*posticus*) were carried on in the laboratory at different times, always with 90–100 per cent mortality from the fungus. The infection cages varied from tightly closed tin tobacco boxes with bottom layers of moist sand or garden loam on which the weevils and their food were placed, to open glass battery jars on the bottoms of which was placed moist sand or garden loam to a depth of one-half inch to three-fourths inch, the food and weevils being then introduced and the jars closed with cheesecloth tops, thus allowing the air free access to the interior of the cage. These cages were moistened from time to time as they

[1] DeBary, A.: Comparative Morphology and Biology of the Fungi, Mycetozoa and Bacteria. p. 372 Oxford.

dried out, and fresh alfalfa was supplied as necessary. All cages were placed in a conservatory having two walls glassed in and connected with a room of the laboratory, thus insuring more light and circulation of air than is ordinarily found indoors. All cages were disinfected before use by being washed in 20 per cent carbolic acid and rinsed in tap water. Infection was, with the exception of the first experiment, by introduction into the cages of insects showing well developed fruiting fungus. Alfalfa not eaten by weevils was allowed to accumulate as débris in the bottom of the cages.

Experiment I

March 23: Five weevils were infected by contact with a fungus-covered weevil in a moist chamber for 2 hours. They were then placed in a battery jar cage partially filled with moist sand and alfalfa was introduced as food.

April 3: One weevil dead.

April 7: Second weevil dead.

April 9: Third weevil dead.

April 10: Fourth weevil dead.

April 25: Fifth weevil dead.

All developed a pure growth of *Sporotrichum globuliferum* within two to three days of death.

Experiment II

March 25: Thirteen weevils were placed in a small vial with a fungus-covered weevil and left in a moist chamber for 4 hours. The weevils were then placed in a tight tin tobacco box partially filled with moist sand. Alfalfa was placed in the cage as food. Later a weevil showing a good growth of fungus was placed in this cage under the alfalfa.

March 30: Three weevils dead, 2 from fungous disease; 1 from unknown cause.

April 3: One more weevil dead. A living weevil which seemed to be ailing was dissected. The blood of the abdomen contained several fungus hyphæ of various lengths. The blood of the thoracic region showed more numerous fungus hyphæ and these were generally longer and further advanced than those in the abdomen. Incipient branching of the hyphæ was observed in several cases. Fungus bodies practically identical with the "cylinder-gonidia" observed in Van Tieghem cells were observed in the blood.

April 6: Contents of cage were examined. Found 12 dead weevils.

All developed typical fungus, except the weevil noted March 30 as dead from unknown cause.

Experiment III

April 5: Twelve weevils were placed in a tobacco-box cage with a fungus-covered specimen. Moist sand and alfalfa were used as in Experiment II.

April 6: One weevil dead of fungus. This weevil was probably infected when collected.

April 8 and 11: One weevil was dissected on each date without finding signs of fungus.

April 15: All weevils dead.

April 21: All developed typical fungus except the two dissected.

Experiment IV

April 7: Twenty weevils were placed in a tobacco-box cage as before with moist sand.

April 8: One weevil dead from unknown cause. One living weevil was dissected but no signs of fungus were seen.

April 15: Two weevils dead.

April 16: An enfeebled weevil was dissected. The abdomen and thorax were well supplied with fungus hyphæ varying from "cylinder-gonidia" to long, considerably branched hyphæ.

April 18: A dead weevil showing no exterior growth of fungus was dissected. The body was found to be packed with a reddish-brown mass of fungus hyphæ.

April 20: All weevils dead but one.

April 21: Last weevil dead.

All not dissected developed typical fungus.

Experiment V

April 16: Fifty weevils were placed in glass battery-jar cage, the bottom of which was covered with garden loam. The cage was infected by placing in it 4 fungus-covered specimens.

April 21: Twenty-five more weevils placed in this cage.

April 28: Weevils dying in numbers.

May 7: All weevils dead.

Experiment VI

May 8: Thirty weevils were placed in a battery-jar cage with garden loam as before. The cage was infected by the introduction of several fungus-covered specimens.

May 18: All but 3 dead.

May 20: All dead and all developed typical fungus.

Experiment VII

Aug. 7: Twenty-two weevils reared from pupæ about July 15 were placed in a battery-jar cage with moist sand. Cage was infected by introducing several fungus-covered specimens.

Aug. 20: Several weevils dead.

Aug. 31: A few still alive.

Sept. 18: Four weevils still alive.

Oct. 13: Last weevil dead.

All developed typical fungus.

Experiment VIII

Sept. 30: Fifty weevils collected from a ditch bank, were placed in a battery-jar cage with moist garden loam; infection brought about as in previous experiment.

Oct. 14: Three dead.

Oct 20: Many dead and showing fungus.

Nov. 4: Forty-five weevils dead of fungus, 4 weevils alive, 1 lost.

Nov. 18: One weevil still alive.

Nov. 20: Dissected the last living weevil. Found a few scattering *Sporotrichum* "cylinder-gonidia" in the blood. Most of them were of irregular or indistinct outline as if undergoing cytolysis.

This cage contained 47 weevils dead and showed typical exterior growth of *S. globuliferum*, 1 weevil dead with body filled with the hyphæ of the typical fungus, 1 weevil with growth of *Aspergillus* sp., probably dead from some other cause.

Check to Experiment VIII

Sept. 30: Started cage of 50 weevils under exactly similar conditions to Experiment VIII except that no fungus was intentionally introduced.

Nov. 25: One dead of *S. globuliferum*.

Dec. 18: Forty-five living weevils, 3 dead (2 of *S. globuliferum*), 1 lost, 1 killed by *S. globuliferum* removed.

Note: No *Sporotrichum* appeared in this cage until 2 months after starting experiment.

Summary of Infection Experiments

In the early experiments when tight, unventilated tin boxes were used, complete mortality from the fungus disease occurred within two weeks, in the case of Experiments II and III in 12 and 10 days respectively. Conditions were of course optimum for the growth of the fungus and very unnatural for the weevil.

In the early battery-jar cage experiments under supposedly less favorable conditions for the growth and spread of the fungus, almost as good results were attained, the majority of the weevils dying of the disease within ten days to two weeks. In the case of Experiment VI, where the weevils were less crowded than in any experiment but Experiment I, all died in 12 days. In the case of Experiment I where conditions most closely approached those in the field in the proportion of the number of weevils to the area of the cage, a somewhat longer time was necessary to kill 3 of the 5 weevils, namely 17, 18 and 33 days respectively. The last weevil to die in this cage probably either escaped or conquered the first infection which in this case was attempted by a short exposure to the fungus spores followed by isolation in a clean cage.

In the later experiments with weevils of the new generation, considerable resistance to the fungus developed. At this time a majority of the weevils were killed in 3 weeks, but often several were able to survive for one or two months. Some of this difference in mortality between the two seasons may possibly be attributed to the fact that the cages dried out faster in mid-summer and fall, so that often the sand or dirt in the cage became almost bone-dry before this condition was rectified by sprinkling the interior of the cages. However, dissections and blood examinations of some of the weevils from these cages indicated that some individual weevils were more or less immune at this season. This immunity is deduced from the cytolytic phenomena observed in the blood of the weevil dissected under Experiment VIII.

It may be of interest to note in this place that Hypera adults appear to be rather resistant to the well-known entomogenous fungus *Metarrhizium anisopliæ* Sorokin. Laboratory attempts to infect weevils

with this fungus obtained from Elaterid larvæ from Hagerstown, Md., through the courtesy of Mr. J. A. Hyslop of the U. S. Bureau of Entomology, showed less than 50 per cent mortality from this fungus after nearly three months' exposure to the fungus under conditions exactly similar to those of the *Sporotrichum* experiments. Moreover, it took almost a month to kill the first two weevils by means of this fungus.

CONCLUSION

The entomogenous fungus, *Sporotrichum globuliferum* Speg., develops spontaneously as an infectious disease of the alfalfa weevil, *Hypera variabilis* (*posticus*) on the bench lands of the Salt Lake Valley in the early spring. Infection experiments show the weevil to be very susceptible to fungus infection at this season, a complete mortality from the fungus being secured in breeding cages in usually two weeks' time. The ground-frequenting habits of the alfalfa weevil at this season render it particularly liable to infection from contact with fungus-covered insects.

The new generation of weevils is less susceptible to the fungus during the periods of æstivation and hibernation in the summer and fall. Moreover favorable conditions for the growth and spread of the fungus are unlikely to occur in Utah at this time.

The period of greatest mortality from the fungus disease, coinciding as it does with a period of great potential injury from the pest, namely, the oviposition period, makes the fungus worthy of record as a natural enemy of the alfalfa weevil.

H. S. SMITH: Does the fungous disease attack only the adult weevils?

L. P. ROCKWOOD: The larvæ and pupæ are also attacked but because they are usually on the leaves and tops and not on the damp ground they seldom become infected.

DR. E. G. TITUS: There are about 30 hosts attacked by this fungus, but in no case has it been noticed to be of economic importance though under observation since 1910.

H. S. SMITH: There is a fungus which works very effectively on the alfalfa weevil in Italy, attacking the larvæ.

L. P. ROCKWOOD: *Sporotrichum* is very widely distributed and is of more importance than it is usually credited with.

CHAIRMAN H. J. QUAYLE: The next paper by Mr. Asa Maxson will be read by the secretary.

SOME UNPUBLISHED NOTES ON PEMPHIGUS BETÆ DOANE

By Asa C. Maxson, *In charge of Insect Investigations for the Great Western Sugar Company, Longmont, Colo.*

In April, 1912, the writer began a study of the life-history and habits of the sugar beet root-louse, *P. betæ* Doane, in coöperation with the Colorado Experiment Station. The work was done at Longmont, Colo., the funds being furnished by the Great Western Sugar Company in whose employ the writer has been since 1910.

While the main facts in connection with the life-history of this insect have been given by Gillette and Bragg, Journal of Economic Entomology, vol. 8, no. 1, p. 97, there still remain a number of unpublished observations which have a bearing upon the life-history and habits as well as the control of this pest.

Hibernation of Apterous Form

In order to ascertain to what extent the apterous lice live over from season to season in the soil of old beet fields, three fields were examined during the second week of April. At this time the spring field work had not begun and no weeds had started in the fields. The examination was made by digging holes about 10 inches in diameter and from 8 to 10 inches deep. The soil from these holes was carefully examined by crumbling it with the fingers.

In field No. 1, which had grown sugar beets continually for at least 6 years, holes were dug at both ends and in the centre. Of the 101 holes dug in this field the soil from 52 per cent yielded living root-lice. The east end of the field is higher and drier than the west end. Sixty per cent of the diggings in this part of the field yielded living lice while but 25 per cent of those at the west end produced lice. In the centre section of the field 55 per cent of the diggings produced lice.

Field No. 2 grew its first crop of sugar beets in 1911, the previous crop being alfalfa. The soil from 56 per cent of the holes dug in this field yielded living lice.

Field No. 3 grew its first crop of beets in 1911, also, following a crop of barley. In the soil from 76 per cent of the holes dug in this field living lice were found.

Hibernating Lice as a Source of Crop Infestation

In the determining of this point three cages 8 x 3 x 3 feet, consisting of a light frame work covered with muslin, were used. These cages were placed at the east end of field No. 1. They were placed end to

end and about 8 feet apart. A board 1 x 12 inches formed the base of the cages and this was sunk into the ground to a depth of 10 inches. These cages were put in place May 8 at which time the young stem-mothers on the cotton-woods were in the first and second instars. Beet seed was planted in cage No. 1 and in the spaces between the cages on this date. Seed was planted in cages Nos. 2 and 3, June 4 and 27, respectively. After the seed was planted in the cages they were not opened until the migration of lice from the cottonwood trees was practically over when the weeds were pulled and the beets irrigated.

September 28 the beets in the cages and in the spaces between them were dug and a careful examination made for root-lice. It was found that the beets in cage No 1, the earliest planted one, were all infested. Those in cage No. 2 were infested but to marked degree less than those in cage No. 1. The beets in cage No. 3 were entirely free of lice. All beets in the spaces between the cages were infested, also.

Host Plants

Our knowledge of the apterous forms of the various species of the genus Pemphigus is so limited that it would hardly be safe to say that all root forms of this genus represent any particular species. For this reason in discussing the host plants it should be remembered that some of them may not be hosts of *P. betæ* since a determination of the apterous lice is not possible.

The perennial plants which have been found to be hosts of *Pemphigus* sp. are of especial interest because of the fact that they play a double rôle in the life-cycle of these insects. The following perennials were found to be hosts of *Pemphigus* sp.: Yarrow, *Achillea* sp.; wild aster, *Aster multiflora; Solidago* sp.; *Rumex* sp.; *Agropyron* sp.; and *Polygonum aviculare*.

Summer colonies were found on the roots of *Chenopodium album*, garden beets, sugar beets, and *Cycloloma atriplicifolium*. *Pemphigus* sp. have been reported on carrots and sweet clover as well as alfalfa; however, the writer has never been able to verify these reports. A very close examination of many alfalfa fields, while the alfalfa was being plowed up, has never revealed a single Pemphigian on the roots. Lice of this genus have been repeatedly taken on turnips in the south.

Effects of Lice on Sugar Content and Yield of Sugar Beets

From the standpoint of the sugar manufacturer this is a very vital point. The reduction of the per cent of sugar in the beets not only reduces the quantity of sugar which can be made from a given acreage which means a smaller year's profit for the manufacturer but also

makes the manufacture of sugar at a profit impossible if the sugar per cent drops below a certain level.

In order to ascertain the effect of the beet root-louse upon the percentage of sugar in the beets a series of 61 five-beet samples was taken during the second week of September 1912. All of these samples came from an area not to exceed 20 square rods in extent. Thirty-one of these samples were made up of beets free or nearly free of root-lice, the remaining thirty being made up of beets which were infested but not to a degree sufficient to effect their appearance. The uninfested samples averaged 14.62 per cent sugar. The lowest sample tested 12.9 per cent and the highest 15.3. The infested samples tested 13.85 per cent as an average and ranged from 11.7 per cent to 15.7. The difference in favor of the uninfested samples was 0.77 of 1 per cent in sugar content and 2.11 per cent in apparent purity.

Again in 1914 a similar test was made. This time 40 samples were taken, 20 infested and 20 uninfested. The former averaged 13.12 per cent sugar, the individual per cents ranging from 11.2 to 16.9 per cent. The latter averaged 14.06 per cent with a range of from 12.2 to 16.8 per cent sugar. Of the infested samples but one was above 14.4 per cent while of the uninfested there were 6 above this point. The uninfested samples averaged 0.94 of 1 per cent higher than the infested.

In weight the infested samples averaged 4.98 lbs. The heaviest sample weighed 6.5 lbs. and the lightest 3.5 lbs. The average weight of the uninfested samples was 6.7 lbs. The heaviest weighed 9 lbs. and the lightest 5.5 lbs. It is a well-known fact that among beets grown under the same conditions the large ones average lower in per cent sugar than the small ones. This being the case the small infested beets should have contained a higher per cent of sugar than the larger uninfested ones had not the effect of the lice been the cause of the lower weight as well as sugar content. Figuring from the above and assuming that we have a perfect stand of beets which would mean a beet every foot in the row and the rows 20 inches apart or 26,000 beets per acre the lice reduced the yield 4.55 tons per acre. However, not more than 50 per cent of the beets of a field could safely be considered as infested to this degree in the average. This would mean that the loss really was not far from 2.25 tons per acre as a result of the root-lice.

At an average price of $5.80 per ton this means a direct loss of $13.05 to the grower, without taking into consideration the loss in sugar per cent.

Control Measures

It has been shown by J. R. Parker, of the Montana Experiment Station, that irrigating at the time the spring migrants of the root-

louse are leaving the galls on the leaves of the narrow-leaved cottonwood trees has a very marked effect on the number of lice on the beets at harvest time. The writer has observed this fact in connection with plots used in determining the relative effects of early and late irrigation of beets. In all cases the plots irrigated during late June have been much freer of root-lice at harvest than those irrigated the fore part of July.

Rotation of crops appear to have no effect upon the degree of infection. In fact many times the first beet crop on alfalfa or grain land is more seriously damaged by root-lice than any other.

Natural Checks

While in the galls the lice are preyed upon by a capsid and the larvæ of a syrphus fly. In the soil many lice are destroyed by the fungous disease, *Empusa aphidis*. The larva of the syrphus fly *S. pauxillus* was taken feeding in a colony on a beet root. The flocculent larvæ of the little lady-beetle, *Scymnus collaris*, has been noted in numbers among the root-lice in the field. The larvæ of *Hippodamia convergens* has been taken feeding upon the root-lice where the soil was cracked about the beet. In California the larvæ of *Scymnus appaculus* is known to feed upon the beet root-louse.

Life-Cycle

The writer has succeeded in following the life-cycle from the gall to the gall in the insectary. Spring migrants of *Pemphigus balsamiferæ* Williams have been taken from the galls and colonized on sugar beets which were grown from seed in sterilized soil and in muslin-covered cages. The sexual forms have been secured on twigs of the narrow-leafed cottonwood tree, *Populus angustifoliæ* on the leaves of which tree the galls appear. These twigs were placed in the cages. This work was done in 1914. The sexuals mated normally and the females produced eggs on the twigs mentioned. In the spring of 1915 the eggs produced larvæ which were placed on a seedling narrow-leaf cottonwood. These larvæ located on the upper side of the leaves just as the buds began to open and there formed the typical *P. balsamiferæ* galls. The migrants from these galls proved to be without doubt *P. balsamiferæ*.

Synonomy

In 1900 Professor Doane described the beet root-louse from the root form in bulletin No. 42, of the Washington State Agricultural College, giving it the name, *Pemphigus betæ*. In the late Thomas Albert Williams' "Aphididæ of Nebraska" which was published in 1910 we have the description of the spring forms and the galls. This form Mr. Wil-

liams gave the name *Pemphigus balsamiferæ*. Professor Doane's name having the priority, Williams' *P. balsamiferæ* must be considered as a synonym of *P. betæ*.

Lice Liable to be Confused with P. betæ

In some collections the spring forms of *P. betæ* are labeled *P. p-venæ* Fitch. The gall of *P. betæ* differs from that of *P. p-venæ* as described by Dr. Fitch by being on the under side of the leaf opening above while Dr. Fitch clearly states that the gall of *P. p-venæ* is on the upper side of the leaf opening below.

Many times there occur on the leaves of the same tree and the same leaf with the galls of *P. betæ* the galls of what the writer is considering *P. p-globuli* Fitch. These galls are on the upper side of the leaf at the base of the leaf. They are nearly circular in cross section while the galls of *P. betæ* are eliptical or narrowly oval in cross section. The alate lice from these galls differ in the number of secondary sensoria on joint VI of the antennæ. *P. betæ* has no sensoria on VI or at best very short oval sensoria which are not raised above the surface of the joint and not as long as the diameter of it. Joint VI of *P. p-globuli* has several annular sensoria. While *P. betæ* from the galls has always taken to the beet in the cages the migrants of *P. p-globuli* have uniformally refused to colonize on the beet roots.

Range of P. betæ

No report of the occurrence of *P. betæ* has been recorded from any locality east of western Kansas and Nebraska. The writer has collected *Pemphigus* sp. in most of the states west of the Mississippi but has never taken *P. betæ* either on sugar beets or on any Populus sp. east of the points mentioned. The range of the narrow-leafed cottonwood, *Populus angustifoliæ*, is given as from North Dakota to Washington and from New Mexico to California. It is probable that a better knowledge of the locations where these trees occur and beets are not grown in large acreages would reveal the fact that this insect's range extends as far east as that of the host tree.

In Colorado the number of narrow-leafed trees rapidly diminishes as we go eastward from the mountains.

There is a possibility that further study will show that some other of the *Pemphigus* sp. occur on the beet during the summer. The only species which the writer has not used in cage experiments is *P. p-ramulorum* Riley. With the exception of *P. balsamiferæ* all species have repeatedly refused to take to beets.

Chairman H. J. Quayle: This concludes the papers and the

meeting. The first convention has been satisfactory and well worth while. All members should work for the parent branch. This new organization means much not realized before, including the JOURNAL OF ECONOMIC ENTOMOLOGY, the opportunity to present papers and to meet other workers in this important field of scientific work.

The convention is adjourned.

The following paper was received too late for the meeting and is presented for publication in the proceedings for which it was intended.

BUCCULATRIX THURBERIELLA, A PEST OF COTTON IN THE IMPERIAL VALLEY[1]

By E. A. McGREGOR, *Bureau of Entomology, U. S. Department of Agriculture*

On the first of June of the present year a species of tineid larva was found devouring the leaves of cotton in certain fields near El Centro in the Imperial Valley of California. Reared adults were determined by Mr. W. D. Pierce of the Bureau of Entomology as *Bucculatrix thurberiella* Busck, a species which was collected in the summer of 1913 by Mr. Pierce on wild cotton (*Thurberia thespesoides*) at various points in Arizona.

DESCRIPTION

ADULT.—Busck's description[2] of the adult is as follows: "Face tuft, head and thorax white. Antennæ white with dark fuscous annulations. Forewings white; extreme costal edge blackish; an outwardly black streak beyond the middle of costa is continued as a very fine, casily lost line across the wing to a group of black scales below apex, where the cilia is also dotted with black; a few easily lost black scales on basal third of dorsum and a group of black scales on the middle of dorsum is followed by scattered light brown scales. The apical part of the wing above the oblique costal streak is dusted with brown and black scales. Cilia ochreous white. Hind wing and cilia ochreous white. Legs white on the inner side, black exteriorly; tarsi black with narrow white annulations. Alar expanse 7 to 8 mm."

LARVA.—Concerning the larva Busck merely states that it "is dirty white, rough skinned, with prominent white tubercles and with two dorsal rows of black dots, one on each segment. Head light ochreous with black eyespots and reddish-brown mouth parts."

In life the larva is rather of a greenish-amber color. Each segment, viewed dorsally, exhibits the following characteristics; a pair of large black spots at the anterior margin; a transverse row of 6 whitish tubercles situated just behind the black spots and extending from side to side; a second transverse row of similar tubercles midway between the former and the hind margin—all tubercles giving rise to a short bristle. Eighth segment from the head nearly obscured by a dusky area. Thoracic legs blackish. Head light ochreous with black eyespots and posterio-dorsal area of dusky color.

[1] Published by permission of the Chief of the U. S. Bureau of Entomology.

[2] Proc. Ent. Soc. of Wash., vol. XVI, no. 1, March 1914, p. 30.

Economic Importance

During the present (1916) season *Bucculatrix thurberiella* has been one of the few major pests of cotton in the Imperial Valley. One hundred cotton leaves were gathered on June 2 from a field heavily infested with this species, and the infestation was computed as follows:

Leaves (total)	100
Leaves free	22
Leaves supporting larvæ[1]	4
Leaves supporting pupæ[1]	32
Leaves showing work	42
Percentage infestation	78

Subsequent to the above date infestation reached an even higher degree, but by the first of July was somewhat checked by the work of parasites. The Bucculatrix larvæ, however, attained the ascendancy again about the first of August and at the present date (August 8) are probably the most abundant that they have been at any time during the season. In some fields not a leaf is free from the work of the species. Table I presents the results from the examination of 20 leaves picked at random about a field at El Centro, California.

Table I. Occurrence of Immature Stages of *Bucculatrix thurberiella* on Cotton Leaves

Leaf No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Average.
No. mines in leaf	13	76	12	8	15	20	16	18	38	12	20	12	11	5	7	18	28	20	24	5	18.9
No. molting cocoons on leaf	4	4	1	6	2	4	2	4	5	13	5	7	3	6	5	4	16	4	15	2	5.6
No. larvæ on leaf	2	3	4	2	2	1	2	2	4	3	3	6	0	2	0	3	3	1	4	1	2.4

The pest has been found in fields at El Centro, Imperial, Brawley, Westmoreland, Calipatria, Meloland, Seeley and Calexico, which demonstrates that it occurs in every cultivated part of the Valley.

The tineid caterpillar may be found in virtually every cotton field, but it appears to thrive best on plants which, for some reason, are stunted and non-vigorous. A 5-acre field of cotton, "volunteering" from last season's roots which had received no water since the occurrence of a rain in March, was early seen to be very severely attacked. A small plot of seedling cotton (see Pl. 36, fig. 1), growing near a hedge of tall eucalyptus trees, remained stunted for weeks, and these plants became very heavily infested. Tall cotton is similarly attacked (see Pl. 36, fig. 2) but is better able to withstand the work of the pest. When present, cotton clearly shows the effect of the caterpillar, the foliage being riddled and perforated, often, until little more than veins

[1] Also showing damage.

and epidermis remain (Pl. 37, fig. 4). Small, ill-nourished plants are usually killed, while larger plants are often severely injured. Occasionally larvæ feed upon the calyx and involucral bracts which results usually in the shedding of the form. On account of the thickly honeycombed nature of the leaf lesions, which is so characteristic of Bucculatrix-infested cotton, we propose as a common name for this species the "cotton leaf-perforator."

Life-History

The Egg.—The egg is very small, being barely discernible to the naked eye. It is projectile-shaped, pale straw-color, with about ten longitudinal ridges and intervening grooves, giving it a strongly fluted appearance. In addition to this, a reticulate system of smoky-colored mottlings decorate the surface. The egg is placed upright on the leaf, standing on its largest end. No preference seems to be shown in ovipositing as between the top and under sides of the leaf. Since we have been unable to induce egg-laying under control, it is impossible to present data as to the duration of the incubation period. Eggs in out-of-door locations on a few occasions have been observed 24 hours prior to hatching which indicates that the period is somewhat in excess of that interval.

The Larva.—First Instar.—Upon hatching the larva bores into the leaf directly at the point of attachment of the egg and begins to tunnel. The mine lies nearer the upper surface than the lower, and progresses tortuously, ever widening in calibre. The average total length of the tunnel, as determined from a measured series, is about one inch. When this instar is about completed an exit hole is cut through the upper epidermis, and the larva deserts for all time the inner tissue. Upon coming to the exterior the first instar individual occasionally feeds for a brief period on the upper leaf tissue. The time required for the completion of this instar is about three days.

When the feeding activities of this stage are finished the larva weaves a tiny circular web over some slight depression on the under side of the leaf into which it repairs for the first molt. The initial molting web consists of two fabrics, first a "fly" web of loose texture is woven and under this is spun the more compact fabric. A somewhat concealed aperture is left through which the individual makes its exit after molting. A large series of these primary molting webs averaged 1/16 inch in diameter. The molting period covers about twenty-four hours.

Second Instar.—Upon the appearance on the leaf of the second larval instar, feeding at once begins. This may take place on either the upper or the under surface. The leaf tissue is devoured only to the opposite epidermis, but the remaining tissue often collapses, thus forming irregular-shaped lesions (see Pl. 36, fig. 2). After about 1.5 days at El Centro, the larva selects a concavity, normally on the under surface between two large veins, and spins the second molting cocoon. These are similar to the primary cocoons but are larger, averaging about 3/32 inch in diameter. The larva lies in a looped position—head to tail. The quiescent period is determined from our data to be 1.1 days.

Third Instar.—At the conclusion of the second molt the larva of the third instar emerges and at once begins to feed in a manner similar to individuals of the second instar. This is the most aggressive stage and the one causing the greatest amount of injury to the cotton leaf. As a rule, not more than two or three larvæ occur on a single leaf, but occasionally as many as a half dozen have been seen. The last act of the third larval instar individual, after the completion of the pupal cocoon, is the shedding of the larval skin which occupies a position within the cocoon just behind

the posterior end of the chrysallis. Just prior to pupation the color of the mature larva undergoes a change from the olive-green of the active condition to a smoky-drab which is apparently indicative of maturity. The third instar at El Centro required during midsummer about 1.9 days for completion.

THE PUPA

The pupal cocoon may be placed in one of several locations. It is occasionally seen at some point on a leaf; it is often formed on the leaf petioles; but most frequently it is placed at some point along the main or lateral stems (see Pl. 36, figs. 1 and 3). Just before making the cocoon a series of stout, upright bristles is placed in a graceful ellipse so as finally to surround the cocoon. These closely set stalks form a stockade and are intended, probably, as a protection against predatory species.

Table II presents the data concerning the occurrence and distribution of the Bucculatrix pupæ on 32 closely scrutinized plants. These plants were pulled at random from a heavily infested field which averaged 16 inches in height. The examination was made August 8, and the results contained in the following table also afford a very good idea of the degree of infestation at that time.

TABLE II. OCCURRENCE OF PUPAL COCOONS OF *Bucculatrix thurberiella* ON PLANTS

Plant No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Cocoons on stem...	7	15	6	16	[illegible]	11	4	[illegible]	4	5	7	7	7	6	4	4
Cocoons on petioles	2	1	0	2	1	0	0	1	0	1	1	0	0	0	0	0
Cocoons on leaves..	0	0	0	0	1	0	2	1	0	0	0	0	0	0	1	1
Total.........	7	16	6	18	9	11	6	8	4	6	8	7	7	6	5	5

Plant No.	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	Aver.
Cocoons on stem...	6	11	10	4	10	12	7	5	5	8	23	6	7	9	7	5	7.8
Cocoons on petioles	0	3	1	0	2	1	0	1	0	0	6	5	0	0	1	1	.94
Cocoons on leaves..	0	0	3	3	3	3	1	0	0	0	3	0	1	0	0	0	.72
Total.........	6	14	14	7	15	16	8	6	5	8	32	11	8	9	8	6	9.4

In constructing the cocoon each end is woven to a point near the middle, whereupon the larva withdraws into one half of the cocoon and deftly spins a few tie-fibrils between the ends of the opposed fluttings; the gap is then entirely closed with a mesh of cross-fibrils. From the pupal records of a large series of bred individuals we find that the average duration of the pupal period for June and July at El Centro is 5.7 days. The development of the cotton leaf-perforator may be summarized, then, as follows:

	Days
Egg stage..	1 (plus
Leaf-mining stage................................	3
First molt.......................................	1
Second larval instar.............................	1.5
Second molt......................................	1.1
Third larval instar..............................	1.9
Pupal period.....................................	5.7
Total..	15.2

It is very likely that under the most favorable conditions the completion of one generation requires little in excess of two weeks.

Parasitism

At least two species of chalcidid flies have been bred from the Bucculatrix pupæ. Twenty cocoons were collected in the field during the last of June and kept under observation in the laboratory. Of these, 16 gave issue to parasites, thus yielding a computed parasitism of 80 per cent. Many larvæ of the first instar were also being killed at that time by a parasite which attacks them while in the leaf mines. Although we have observed a high mortality among individuals of the mining stage, we have been unable to breed perfect adults from such material. During August, again, the parasitism of the cotton leaf-perforator became heavy. No specific determinations of the parasites have yet been made.

Origin of Pest

The question has arisen in the writer's mind whether Thurberia or cotton (Gossypium) is the original native host of *Bucculatrix thurberiella*. Domestic and wild cotton were planted in the garden of the Bureau's station at El Centro and germinated at the same time. Thus, plants of the two malvaceous genera, of the same age and condition, were present side by side at the time of the appearance of the cotton leaf-perforator. It seems significant that the Gossypium plants early became heavily infested, while the Thurberia plants (growing immediately adjacent) remained entirely free for weeks. Furthermore, as previously stated, no cotton field in the valley has been found free from the Bucculatrix during June, July and August, which condition is also significant.

If Thurberia is the native host of the tineid pest one would naturally expect to find this plant occurring in its usual mountainous environment bordering the Valley. Since the prevailing winds at the time of the first appearance of the insect are from the west, it would be natural to suppose that the migrating individuals originally came from wild cotton occurring in the mountains bordering the Valley on the west—provided Thurberia is the native host of the species. With this possibility in view several trips have been taken into the mountains above mentioned, and a very careful search conducted in an effort to establish the occurrence there of wild cotton. Many favorable places were visited at elevations between 2,000 and 4,000 feet, but no trace of Thurberia could be found. In addition, botanists have not recorded the species from any California point.

Finally, one point in the biology of the Bucculatrix species is very suggestive. We have reference to the stockade of bristles which are

always placed by the mature larva around the cocoon site. To the finest imaginable detail these bristles exactly simulate the hirsute pubescence to be found on the stems and petioles of most cultivated cotton varieties. In length, color, general shape and even in the barbellate character of the hairs the similarity is complete. On the other hand, the Thurberia plant is of an almost glabrous nature, and the sparse pubescence which at times is found on the stems bears no similarity to the stockade bristles of the Bucculatrix cocoon. If, as they doubtless are, these protective hairs are intended to imitate the pubescence of the native host, the Thurberia plant—by this test—should at once be eliminated.

From the foregoing arguments it seems very probable that the Bucculatrix under discussion was originally a native pest of Gossypium species. If this is true it follows that the insect has found its way to the United States from the ancient cotton-growing areas of Mexico and from the insular and maritime regions of tropical America to which cotton is indigenous. In this respect is would constitute a case somewhat parallel to that of the cotton leaf worm (*Alabama argillacea*).

Explanation of Plates 36 and 37

Fig. 1. Severe infestation of *Bucculatrix thurberiella* on young, backward cotton. (Cocoons on stems indicated by arrows.)

Fig. 2. Perforating effect of the pest on the apical foliage of tall cotton.

Fig. 3. Pupal cocoon of *Bucculatrix thurberiella* on stem of cotton plant. ×10.

Fig. 4. 15-inch cotton plant showing perforations and dessication resulting from the work of larvae of *Bucculatrix thurberiella.*

Fig. 5. A 10-inch seedling cotton plant which has been severely injured and retarded by the presence of Bucculatrix larvae.

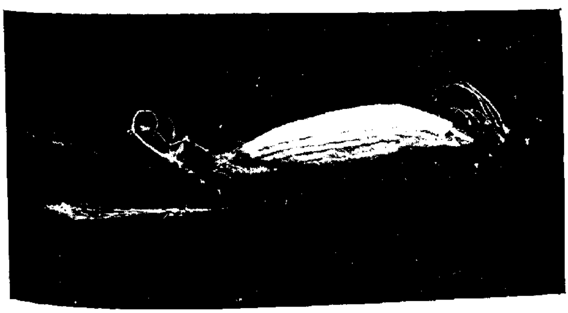
The Hyperparasitic Chalcidoid Planidium on Aphides. October 13, 1915, the writer collected a male specimen of *Aphis pomi* DeG. on an apple tree in the orchard of the Virginia Agricultural Experiment Station, Blacksburg. The specimen was found to possess what appeared to be a supernumerary appendage in the form of a cone-shaped, segmented body or structure which arose from the head, at the base of one of the antennæ. On the supposition that this body might be a parasite, the specimen was sent to Prof. Roland Thaxter of Harvard University, although it did not appear to be of a fungous nature, for examination, with the request that he forward it to Prof. W. M. Wheeler of Bussey Institution, Forest Hills, Mass., with whom the writer had had some correspondence regarding the significance of the body, in case he did not find it to be a fungous parasite. The specimen was forwarded by Professor Thaxter to Dr. Wheeler who identified the body as the first larval stage, or planidium, of a Chalcidoid hymenopteron, the type of larva which was discovered by him on ant larvæ in Texas. (See *Bul. Am. Mus. Nat. Hist.*, Vol. 23, Art. I, 1907; also "The Chalcidoid Genus Perilampus, etc.," by Harry S. Smith, Tech. Ser., No. 19, Pt. IV., U. S. Dept. of Agr., 1912.)

The occurrence of such larvæ on Aphides seems not to have been reported before.

M. T. Smulyan, *Virginia Agricultural Experiment Station*

2

1



3

Work of *Bucculatrix thurberiella*

B

Work of *Bucculatrix thurberiella*

JOURNAL OF ECONOMIC ENTOMOLOGY

OFFICIAL ORGAN AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

OCTOBER, 1916

The editors will thankfully receive news items and other matter likely to be of interest to subscribers. Papers will be published, so far as possible, in the order of reception. All extended contributions, at least, should be in the hands of the editor the first of the month preceding publication. Contributors are requested to supply electrotypes for the larger illustrations so far as possible. Photo-engraving, may be obtained by authors at cost. The receipt of all papers will be acknowledged.—EDS

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It is a pleasure to record the completion of the "Index to American Economic Entomology," covering the important literature from January 1, 1905, to December 31, 1914, so far as the preparation of the manuscript is concerned. The compiler, Dr. Nathan Banks of the United States Bureau of Entomology, is to be congratulated upon having finished his part of the work, an undertaking which makes all economic entomologists his debtors. Thanks are due Dr. L. O. Howard, chief of the Bureau, for detailing the assistance necessary for the prompt completion of this work.

The "Index" contains over 25,000 references, a striking testimony to entomological industry during the decade covered by the publication. Some idea of what this means is indicated by the approximately 500 references to *Aspidiotus perniciosus*, 400 to *Carpocapsa pomonella*, 350 to *Anthonomus grandis*, 200 each to *Euproctis chrysorrhœa*, *Porthetria dispar* and *Musca domestica;* 175 to *Conotrachelus nenuphar;* 100 each to *Heliothis obsoleta*, *Hemerocampa leucostigma*, *Leptinotarsa duodecimlineata*, *Mayetiola destructor* and others.

Many familiar names are followed by fifty or sixty references while hosts of others, some decidedly unfamiliar, are accompanied by a few to a dozen citations culled from every imaginable publication. It is a guide to the latest and best in economic literature and is indispensible to every worker who would keep abreast of the times.

Obituary

GEORGE B. KING

George B. King was born in Lowell in 1848 and died July 24, 1916, at Lawrence, Mass. He was of Scotch descent and, though having only such an education as could be obtained in the public schools of his native city, his interest in nature was so great that, unaided, he took up and mastered many subjects of higher grade. For a time he was a painter by trade, but during the last thirty years of his life was janitor of the Court House at Lawrence.

His first interest in nature took the form of collecting and studying Indian relics. Later he turned to entomology and finally restricted his attention to the study of scale insects. Finding it necessary to this work he took up and mastered several foreign languages, and established a wide correspondence with other students of scale insects both in this country and abroad. His enthusiasm was great and he often worked at his office until very late at night, his hope being to prepare a book on scale insects for publication. Unfortunately his death prevented the preparation of more than a few pages of this work.

He left a widow and five children. His collections have been purchased by the Massachusetts Agricultural College. H. T. F.

TWENTY-NINTH ANNUAL MEETING OF THE AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

The twenty-ninth annual meeting of the American Association of Economic Entomologists will be held in New York City, December 28 to December 30, 1916, under the presidency of Dr. C. Gordon Hewitt. The session will open on Thursday, December 28, at 10 a. m., and will be continued during the afternoon of that day. At 8 p. m., the meeting of the Section on Apiary Inspection will be held. On Friday, December 29, 10 a. m., the session of the general Association will be held. The afternoon and evening of that day will be devoted to meetings of the section on Horticultural Inspection. On Saturday, December 30, the final session of the Association will be held and the meeting will be adjourned at noon on that date unless a lengthy program necessitates holding an afternoon session.

Arrangements have been made for the meeting of the Entomological Society of America to be held on Tuesday and Wednesday, December 26 and 27. The public address will be on Wednesday evening. A notice will be sent to members giving further details concerning the meeting and all are urged to make early hotel reservations in order that there may be no difficulty in securing satisfactory accommodations for the members.

Members desiring to present papers should forward the titles promptly so that the program can be made up and printed in the next issue of the Journal. Application for membership blanks can be secured from the secretary or from Prof. W. C. O'Kane, Durham, N. H., chairman of the membership committee. A. F. Burgess,
Secretary.

Current Notes

Conducted by the Associate Editor

A new building, being erected at the citrus substation, Riverside, Cal., will contain a lecture room and laboratories for entomology.

Prof. T. D. A. Cockerell visited the National Museum for a few days during August to examine the bees of the Pergande collection.

Dr. L. O. Howard has been made chairman, and Dr. W. D. Hunter a member of the subcommittee of entomology of the National Committee for the study of malaria.

Mr. A. H. Ritchie, until recently entomologist in the Department of Agriculture in Jamaica, is now engaged in entomological work for the sugar planters' association of Jamaica.

Mr. C. H. Hadley, Jr., investigator in entomology in Cornell University, has recently been appointed extension entomologist at Pennsylvania State College, State College, Pa.

According to the *Review of Applied Entomology*, Professor H. Maxwell Lefroy was on special duty in Mesopotamia during July and August, in connection with fly investigations.

Messrs. A. J. Grove and L. Harrison have been appointed by the British War Office to advise on entomological problems in connection with the military operations in Mesopotamia.

At a conference regarding the white pine-currant blister rust at Crawford Notch, New Hampshire, September 7, Dr. L. O. Howard, Mr. A. F. Burgess and Prof. W. C. O'Kane were present.

Prof. J. G. Sanders has recently resigned as state entomologist of Wisconsin to accept the appointment as economic zoölogist of Pennsylvania. His work at Harrisburg began September 16.

Dr. James W. Chapman, formerly of the Bussey Institution of Harvard University, is now at Siliman Institute, Dumaguete, Philippine Islands, where he will be engaged in teaching and other entomological work.

Mr. Patricio Cardin, entomologist of the Estacion Experimental Agronomica, has recently been appointed by the president one of the three members of the Commision de Sanidad Vegetal recently established in Cuba.

Prof. H. A. Ballou, entomologist on the staff of the West India Department of Agriculture, visited Washington on July 21, en route to Egypt where he will be engaged for a year in the study of *Gelechia gossypiella*.

Dr. William Morton Wheeler of the Bussey Institution spent some time in Washington during August looking over the ants of the Pergande collection which has been donated to the National Museum by Miss Pergande.

According to the *Review of Applied Entomology*, the services of Dr. W. A. Lamborn have been lent by the British Imperial Bureau of Entomology to the War Office and he is now attached to the Expeditionary Force in East Africa.

Dr. S. B. Fracker has been appointed acting state entomologist of Wisconsin by the commissioner of agriculture, and will have charge of the work of the state entomologist's office until a successor to Professor Sanders is appointed.

Mr. C. B. Williams, formerly a Carnegie entomological student sent to the United States from Great Britain, has accepted an appointment from the Board of Agriculture, Trinidad, to study the parasites of the sugar-cane froghopper there.

According to *Science*, it has been planned to erect on the campus of his alma mater, the University of Virginia, a memorial to the late Maj. Walter Reed of the United States Army, who demonstrated the transmission of yellow fever by mosquitoes.

According to the *Review of Applied Entomology*, second lieutenant R. A. F. Eminson, King's Royal Rifle Corps, who recently made important investigations on the bionomics of *Glossina morsitans* in Northern Rhodesia, has been killed in action.

Prof. Charles T. Brues, Bussey Institution, Forest Hills, Mass., has been engaged temporarily as entomologist to the Health Department of New York City, to study the insects possibly responsible for the transmission of infantile paralysis in the recent outbreak in New York City.

Mr. W. F. Fiske arrived in Washington on August 10. He expects to spend about two months in the country and then return to England. The Imperial Bureau of Entomology contemplates resuming the work on the bionomics of tsetse flies in Africa immediately after the war.

An error regarding the appointments of Prof. David D. Whitney and Homer B. Latimer occurs on page 446 of the August issue of this JOURNAL. It should read that they have been appointed professor and assistant professor, respectively, of zoölogy in the University of Nebraska.

Dr. M. C. Tanquary, assistant professor of Entomology, Kansas State Agricultural College, who was granted a leave of absence in 1913 to accompany the Crocker Land Expedition, has returned to the Kansas Agricultural College and will continue his work in the college and experiment station.

At the Agricultural Experiment Station, New Haven, Conn., an outdoor insectary 10′ x 16′, covered with wire netting and provided with a temporary roof of canvas which can be rolled up, was constructed, early in the summer, for work with the pine sawfly, *Diprion simile* Hartig, and other insects.

The following entomological workers have recently left the employ of the Bureau of Entomology: William B. Middleton, resigned to study entomology at Cornell University; Ray B. Ellis and C. Joseph Manter, Hayward, Cal., appointments expired; Charles E. Smith, Baton Rouge, La., resigned.

Dr. L. O. Howard, chief of the Bureau of Entomology, and Prof. D. F. Marvin, chief of the Weather Bureau, have been appointed by the Secretary of Agriculture to represent the United States Department of Agriculture on the Council of Research which is now being organized by the National Academy of Sciences.

Additional Edibility Tests of Insect Larvæ: In the Bureau of Entomology, Mr V. A. Roberts cooked some larvæ of the squash borer, *Melittia satyriniformis* Hubn.; this dish was sampled by Dr. Howard, and Messrs. Roberts, O'Leary, Duckett, Jacobs and White, all pronouncing it good. Mr. E. H. Gibson has made similar tests of the larvæ of *Plathypena scabra*.

Mr. Arthur N. Rosenfeld, director of the Tucumán Agricultural Experiment Station, Argentine Republic, has recently resigned to take charge of the 25000-acre cane fields of Hileret & Company, Ltd., the largest sugar factory in South America. This firm maintains a private experiment station. Mr. Rosenfeld's address is Santa Ana, Provincia de Tucumán, Republica Argentina.

Recent appointments in the Maryland State College of Agriculture and the Maryland Experiment Station include Mr. C. J. Pierson, assistant in the Department of Entomology and Zoölogy in the college, who will devote his time to teaching; Mr. O. I. Snapp, Fellow in insect investigations in the college and station; Dr. Philip Garman, assistant entomologist in the station, and K. W. Babcock, student assistant in entomology.

Mr. Ignaz Matausch, a member of the New York Entomological Society, and an artist and modeler on the staff of the American Museum of Natural History, died December 14, 1915, at the age of 47. Mr. Matausch constructed many of the large models of insects exhibited in the Hall of Public Health in the museum; he also worked out the life histories of several species of Membracidæ and published eight papers on this family in the *Journal of the New York Entomological Society*.

In the Bureau of Entomology the following transfers have been made as regards locations: R. S. Woglum, Pasadena to Alhambra, Cal.; F. L. McDonough, Quincy, Fla., to Clarksville, Tenn.; W. H. Larrimer, Missoula, Mont., to Charleston, Mo.; A. B. Gahan, College Park, Md., to Berwyn, Md.; R. J. Kewley, College Park, Md., to Columbia, S. C.; W. H. Willis, Boston, Mass., to Newark, N. J.; D. G. Tower, Newark, N. J., and H. L. Sanford, to Brooklyn, N. Y.; J. L. Webb to study horse flies in Nevada and other western states.

Recent appointments to the Bureau of Entomology are as follows: G. M. Anderson and A. J. Flebut, assigned to the laboratory at Tallulah, La.; V. G. Stevens, Walnut Creek, Cal.; Dr. P. A. Boncquet, Southern California, and Prof. H. F. Wilson, Madison, Wis., collaborators; Scott C. Lyon, Oakley M. Shelby, A. D. Bosley, Samuel F. Grubs, Carl A. Wickland, D. M. Rogers, Joe Milam, Kenneth B. McKinney, F. G. Sorrells, Richard K. Catlett, Walter C. Nagle, Louis A. Stearns, L. S. Hale and Edmund H. Vance, temporary field agents in tobacco insect investigations.

A recent visitor at the Drummond Laboratory of the Bureau of Entomology was Mr. C. Hanslope Bocock, assigned by the British Board of Agriculture to study diseases of adult bees in the United States. The so-called "Isle-of-Wight" disease, or Microsporidiosis, is reported to have caused extensive losses in Great Britain, and the object of this investigation is to learn something of the diseases of adult bees in America and throw some light on the conditions observed abroad. Mr. Bocock spent a month recently with Dr. Burton N. Gates, Massachusetts Agricultural College, Amherst, and will visit other parts of the United States.

A conference was held at the office of the health commissioner of New York City, August 10, at 2 o'clock p. m., to plan an entomological survey with particular reference to the fly problem as a possible means of transmission of infantile paralysis (Poliomyelitis) in New York City and vicinity. Those attending the conference were as follows: Dr. Haven Emerson, Health Commissioner, New York; Dr. W. H. Frost and Dr. Freeman of the United States Public Health Service; Dr. M. B. Mitzmain, entomologist of the United States Public Health Service; Dr. E. P. Felt, state entomologist, Albany, N. Y.; Dr. T. J. Headlee, state entomologist, and C. H. Richardson, assistant, New Brunswick, N. J.; Prof. Charles T. Brues, Bussey Institution, Forest Hills, Mass.; Dr. W. E. Britton, state entomologist, New Haven, Conn.

The appropriation bill for 1917, which took effect on August 11, carries a total for the Bureau of Entomology of $868,880, an increase of $38,980 over the amount appropriated for the fiscal year 1916. The increase is distributed over a number of lines of work, among them the grape berry-moth, insects transmitting diseases of cucumbers, tobacco insects, clover insects in the Northwest, extension work in apiculture, and live stock pests in the West. Thirty-four clerical and subclerical positions throughout the Bureau are placed on the statutory roll, and provision is made for the payment for medical supplies and service for the immediate relief of foremen, scouts, laborers and other employees injured while engaged in hazardous work in the prevention of the spread of moths. This provision is similar to one applying to the Forest Service which has been in operation for several years.

The Governor of Minnesota has allowed an emergency appropriation for the use of the State Entomologist for fighting White Pine Blister Rust in Minnesota, with the implied promise that more money will be available if necessary. The work has been pushed vigorously during the summer. Only two localities have been found in which the rust exists, and most vigorous methods of eradication are being pushed at these places. Nurseries of the state have been combed for other evidences of the disease, but it is believed that the two localities mentioned are the only places involved at the present time.

The Plant Pathology Division of the Minnesota Experiment Station is coöperating in an advisory capacity in this work, as well as the Bureau of Plant Industry, which is also aiding the work financially. Federal Inspector Pierce has made several trips to the state and taken part in various conferences. The Entomologist has had four to eight men in the field most of the time. One infection has been traced as coming directly from Wisconsin, which state received diseased trees from Germany. The source of infestation in the second locality where the disease was found, is believed to have been an European nursery whose locality is not yet known.

Cylas Formicarius Fabr. in Flight. While riding on a street car at night between Rio Piedras and San Juan, P. R., I was interested by noticing several beetles that were flying around inside the car, evidently attracted by the light. On catching one of them I was surprised to find that it was a specimen of the sweet potato weevil, *Cylas formicarius* Fabr., which was supposed to have little or no power of flight. The place where this specimen was taken was at least a good half mile from the nearest patch of sweet potatoes, so in Porto Rico, at least, this beetle has developed strong powers of flight and doubtless spreads itself in this way. This species has also been observed to fly into houses at night to the light in Rio Piedras.

Richard T. Cotton,
Assistant Entomologist, Rio Piedras, P. R.

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